

COMMONWEALTH



OF AUSTRALIA

Council for Scientific and Industrial Research

BULLETIN No. 157

Studies in the Biology of Australian Mullet

1.—Account of the Fishery and Preliminary Statement
 of the Biology of *Mugil dobula* Gunther

(Division of Fisheries—Report No 9.)

By

G. L. KESTEVEN, B.Sc.

MELBOURNE, 1942

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C O N T E N T S.

	<u>Page</u>
Foreword	5
Summary	6
1. INTRODUCTION	7
2. DESCRIPTION OF THE FISHERY -	
(i) The Habitat of the Fish	9
(ii) The "Source" of the Travelling Schools	12
(iii) Methods and Seasons of Fishing	12
(iv) Marketing	16
(v) Existing Control	17
3. BIOLOGY -	
(i) Methods, Collection of Samples, etc.	20
(ii) Species	22
(iii) Raciation	23
(iv) Weight-length Relation, Condition Factor, etc.	29
(v) Age Determination and Growth Rate	33
(vi) Gonad Maturation, etc.	48
(vii) Spawning, Embryonic and Larval Life	52
(viii) Post-larval Life	54
(ix) Migration, Tagging Experiments	54
(x) Feeding	60
(xi) Parasites and Abnormalities, Earthiness	61
(xii) Summary of Biology	62
4. CONDITION OF THE FISHERY -	
(1) Economic Evidence	64
(ii) Fishermen's Reports, etc.	76
(iii) Biological Evidence	77
(iv) Discussion of the Question of Depletion	79
5. SUGGESTIONS FOR CONTROL -	
(i) Case for Restriction of Fishing	84
(ii) Inadequacy of Existing Control	87
(iii) The Basis for Determination of Restriction	88
(iv) Proposed System of Control, etc.	89
6. ACKNOWLEDGMENTS	91
7. BIBLIOGRAPHY	92
Tables	99

War time economy requires
reduction in the Council's expenditure
on publication. It is hoped that the
adoption of the photo-lithographic pro-
cess will be for a brief period only.

FOREWORD.

Until 1915, when the New South Wales State trawling industry began operations, the fisheries of Australia were essentially inshore in character. Since then the inshore fishery has continued with little or no moderation of intensity. Working with seine nets, set nets, and lines, and operating on ocean beaches, in estuaries, lakes, and rivers, the fishermen catch mullet, bream, blackfish, salmon, garfish, and other species. Most of these fish spend the greater part of their life, if not all of it, within the inshore waters; few of them go more than a mile or two beyond the shore while, on the other hand, the incursion of offshore species is exceptional. It must be realised that, in spite of the along-shore migration of the more important species of this fishery, the fishery is compact and restricted both in its distribution and, probably, in the magnitude of its stocks. The truth of this is shown in the degree of depletion revealed in certain areas of the fishery: in New South Wales and Western Australia the depletion is unquestionable; in Queensland, Victoria and South Australia the signs are not so clear, but the conclusion is probably the same.

In this paper, an examination has been made of the economics of the inshore fisheries of Australia, and, where possible, of the mullet fishery in particular. An investigation has been made of the biology of the mullet (*Mugil dobula*) as probably the most important of the inshore species. The result of this work is to show that this fishery is undoubtedly being over-fished and that more restrictions should be placed upon the operatives of the industry in order that the stocks might be allowed to recover and possibly improve beyond earlier levels. A scheme of control is submitted and, at this juncture, responsibility rests with the various State administrative bodies to implement these recommendations.

H. Thompson.

Chief, Division of Fisheries.

S U M M A R Y.

1. The mullet, *Mugil dobula* Gunth., is taken in the course of onshore fishing operations on ocean beaches and in coastal lakes and streams. The nature of the habitat occupied by the mullet is described, and an account is given of the methods, seasons, marketing, and control of this fishery. This fishery is in a very impoverished condition.

2. An investigation has been made of the biology of the principal species of mullet of Australia, viz. *M. dobula*. A preliminary statement is made on the natural history of that species.

3. The present condition and past history of the mullet fishery has been examined on the basis of the biological investigations, and of statistics held by the State Departments. This examination reveals that a condition of serious depletion exists.

4. A scheme for immediate and future action to secure restoration of the fishery is submitted.

Studies in the Biology of Australian Mullet

1.—Account of the Fishery and Preliminary Statement of the Biology of *Mugil dobula* Gunther

1. INTRODUCTION.

The onshore fishery of any country is naturally developed before its offshore fisheries, since it is more accessible and attended by less hazard than the offshore fishery. It is prone to early depletion, because the factors which lead to its early development also lead to its fullest exploitation before other fields are attacked, and the inception of an offshore fishery may be taken to indicate that the onshore fishery can no longer meet the requirements of the market, either because of its own depletion or because of market expansion. Where the onshore fishery is exhausted the problem arises of securing some rehabilitation. Where again market demand exceeds the capacity of the onshore fishery, and this greater demand is met by offshore operations, the possibility exists that on occasion the offshore fishery will be unable to meet the demands and a sudden excessive call will be made upon the onshore fishery. It is incumbent upon the responsible persons to exercise judicious caution at such times to secure the greatest allowable yield from the fishery, but it should be remembered that there also rested upon them the earlier responsibility of judicious management of the fishery so that in normal years its yield might be high while in years of emergency the well sustained stocks might be capable of a temporarily greater yield. It will be shown in the following pages that the Australian Mullet (an onshore fishery) is in some places seriously depleted, and that in others it is approaching dangerously near to a condition of exhaustion: it will also be shown that under the circumstances which now prevail, those of almost total fishery, there is no possibility of extending the catch to meet the present call of emergency. In spite of the urgent demand for supplies of fish, the only sound course of action is one of conservation designed to restore the stocks and to control the fishing intensity at a level compatible with the capacity of the stocks to secure recruitment.

The tasks presented, from the investigational point of view, consist of discovering the present condition of the fishery and of making an analysis of the stocks being fished, and, upon the basis of the findings, of drafting a system of control. Such a system should be so designed as to be adjustable to fluctuations in the stock and to economic changes and should be accompanied by a programme of research whose ultimate aim would be an assessment of (1) the carrying

capacity of the habitat of the species under examination, (2) the replacement ability of the species, and (3) the environmental resistance to the full expression of such ability.

The Australian mullet fishery is worth, wholesale, some £150,000 to £200,000 per year. Mullet represents some 50 per cent.* of the Brisbane market handlings and probably a higher percentage of the New South Wales onshore handlings. The species is very important to the fresh-fish trade and, provided supplies can be maintained, it will probably hold its position as a staple item of that market. On the other hand, just as it can be shown that the fishery is urgently in need of control in respect of intensity of fishing, so it can be shown that the fishery is lamentably controlled from the marketing point of view. Each year there occur periods of glut conditions† during which the value of the fish is considerably depressed. Sometimes, in these periods, the fishermen find their catches a liability to them rather than providing even a modest return for their labour. At these times the markets are subject to the operations of middlemen to whom these months offer an exceptional opportunity to secure large quantities of fish at relatively low cost, a large part of which moreover is offset by the value of roe which the travelling fish at that time carry. Large quantities of gutted fish are set down at such times in refrigeration to be sold at greater prices later in the year when the fish become scarce. It will, therefore, be obvious that the catches of these months, which are shown below to be of considerable biological significance, benefit only a small proportion of the community: the fisherman receiving little or no return and the consumer receiving no reduction in the price of the fish.

Such conditions as these, which are examined below from biological and economic points of view, justify the presentation of a scheme for systematic control of the fishery upon sound biological and economic principles.

History and scope of present investigations: During 1934-1935, Professor W.J. Dakin of Sydney University instituted enquiries along the coast of New South Wales as to the habits of the sea mullet. In those years Professor Dakin sought to establish the major features of the biology of *M. dobula*, above all to discover the spawning habits. Plankton nets were used in a search for eggs and larvae, and fish were examined in a search for mature ova and sperms. The work was unsuccessful and was resumed at the travelling season of 1937, when the present author (having in that year joined the New South Wales State Fisheries Department) was co-opted into the study. In view of the importance of *M. dobula* among the other species in New South Wales littoral waters, the investigation of its biology was made a major project for the present author during 1937, and market measurements were begun towards the end of that year. During 1938 tagging operations were begun, and the full programme developed. When the author joined the Council for Scientific and Industrial Research in 1939, he was enabled to take his data and material with him and to continue the study.

These studies have been prosecuted by means of examination of market stock, in the field and in markets in Queensland, New South Wales, Victoria, and Western Australia, principally. Non-marketable stock have been

* See Table 18

† See Lindsey et al. (1934)

secured by special fishing operations. Plankton nets have been used in the search for eggs and larvae. The methods of collection and treatment of biological material are discussed in the relevant sections.

Although the present study refers principally to *M. dobula*, the study of the lesser species is proceeding and it is hoped to present reports on the systematics of the family and on the biology of the lesser species in the near future.

Although most aspects of an investigation of the biology of a fish species have been touched in this study, the treatment of none of these aspects is exhaustive. The objective at this stage has been to learn such part of the biology as it was necessary to know in an examination of the possibilities of depletion and in deciding upon immediate measures for restoration of the fishery. It is hoped that fuller reports of certain of the sections may be published later.

2. DESCRIPTION OF THE FISHERY.

The fishery for mullet operates along almost the entire eastern coast of Australia, along the eastern half of the South Australian coast, and along the Western Australian coast from Albany to Shark's Bay. There are some thirty species of mullet but only five are of economic importance, and the bulk of the fishery is made up of the capture of two species: *Mugil dobula* (sea mullet), and *Agonostomus forsteri* (yellow-eyed mullet). *M. dobula* is by far the most important because of the size to which it grows and because of the size of its stocks, which permit large captures.

M. dobula has a two-phase life: the greater part of the year is spent in the rivers and lakes of the coast, and a few months are spent (by the mass, as distinct from individuals, upon which information is incomplete) in moving along the coast in a spawning migration. This two-phase existence has evoked a corresponding two-phase fishery.

(1) The Habitat of the Fish: (Fig. 1.)

The major part of the life of mullet is spent in the coastal lakes and rivers and bays in fresh and brackish waters. A smaller portion of its life is spent in truly marine water during various coastwise migrations. The number, nature, and extent of these lakes, etc. is important since they constitute a restricted habitat for the population: the effect of having a limited extent of such waters is shown in the condition of the Western Australian fishery (see pp. 77 and 79).

The three coastal regions mentioned above are alike in broad features, principally in the possession of the shallow coastal lakes, but nevertheless each has its own character^{*}. The eastern section, extending from Port Phillip Bay to Mackay, is characterised by a great number of lakes, bays, and streams, and by the narrowness of the coastal plain in

* See Taylor (1906) and (1911), also Coun. Sci. Ind. Res. (Aust.), Pamph. 42. (1933).



Fig. 1 - Distribution of mullet. Showing the approximate extent of coast along which *M. dobula* and *A. forsterii* are caught during fishing operations.

which these lie. This section is also quite distinct from the other two regions in the degree of rainfall of the plain and in its supporting mountain range. The South Australian section is a long sandy coastline sweeping north-west; close upon the coast there is a long series of narrow lakes, and the large, wide Lake Alexandrina. Behind these lakes there is a very wide hinterland of low country rarely of greater altitude than one hundred feet; on this the rainfall is not high. In the north there are a number of open bays. The Western Australian section has relatively few streams or lakes similar to the Eastern Australian waters, and the streams are short, lying in a narrow plain backed by the Western Australian massif. The streams have an especial hydrological regime based upon a rainfall calendar differing from that of the other waters.

A classification grouping the waters which are occupied by mullet according to relative importance of streams etc., and the association with the neritic water, establishes six categories as follows:- (a) ocean beaches and open bays such as Twofold Bay, Byron Bay; (b) half-closed bays, such as Moreton and Hervey Bays, receiving a number of streams of various sizes; (c) rivers with drowned valley estuaries, such as Port Hacking, Port Jackson, and Broken Bay; (d) streams directly traversing the coastal plain and communicating with the open sea; (e) streams, generally of fair size, which are expanded along their course, either directly or laterally, into broad and mostly shallow lakes, e.g. Clarence and Myall Rivers; (f) shallow coastal lakes supplied by small streams and formed by the closure by sand bars of small bays, etc. Within these topographical types there are marine (neritic), brackish, and fresh-water habitats. The significance of the classification lies in the relative extent of each of these habitats, the times at which they are occupied by the mullet for various biological purposes, and finally the opportunities offered to fishing. Thus the waters of type (a) and parts of the waters of type (c) are occupied by mullet chiefly in the course of migrations, and their importance is for the presence of "fishable" beaches. It is assumed* that mullet spawn at or near the mouths of estuaries and of certain bays, possibly of types (b) and (e) above. Further there is evidence that larval and post-larval life is spent within the estuaries, that the period of adolescence is mainly spent in the shallow bays and the lakes, and that mature fish (recovering or otherwise) occupy the deep waters, fresh-water in winter and brackish in summer. The availability of such grounds is naturally important, and clearly the size of the stocks is a function of the size of the grounds. Waters of type (e), including Clarence River, probably afford the greatest amount of such ground: the truth of this is supported by the greater catches in such waters and in waters (such as Byron Bay) north of these, where catches are really drawn from fish from the rivers south of them. Waters of type (f) present some hazard to the fish in that in some years the sand-bars become complete barriers and close off the lake, as a result there follow changes in the hydrology. More important still, such enclosed stocks may become subject to excessive fishing, as has happened in the Tuggerah chain of lakes in New South Wales, during 1939 and 1940.

Finally, other variations from normal hydrological regimes which are of importance are the occurrence of floods and droughts. Floods are responsible for driving travelling fish away from estuaries. Droughts may cause extensions of the brackish area upstream carrying the mullet with them.

* See p. 52.

(ii) The "Source" of the Travelling Schools:

Since the "source" of the travelling schools has given rise to considerable controversy, and since also, a clear understanding of the role of such schools in the life-history and in the fishery of the mullet is important in developing a policy of control, it will be of advantage to devote time here to assessing the arguments presented, in relation to their occurrence.

Mullet appear in schools on the New South Wales coast at Twofold Bay near the middle of February. This is the customary time and place, but sometimes the appearance is made earlier, at Mallacoota. The Gippsland Lakes are immediately south of Mallacoota, and the streams flowing into these lakes (Nicholson, Mitchell, etc.) are occupied by large mullet. Fishermen and others assert that the fish of the Nicholson River never migrate, but one fish tagged in that river has been recovered in Myall Lakes* and there seems every reason to assume that this stock normally initiates the migration each autumn. The hypothesis is, therefore, advanced (and substantiated below) that the migration begins in north-east Victoria in January-February and is maintained *en échelon* northwards by successive contributions lake by lake in turn (see Fig. 2).

In the first place, fishermen have asserted that the river and lake fish are quite distinct from the sea fish, and are not merely different phases of the one life-history. Whilst it is true that the lake fish are slimy and dark and the sea fish are clean and shining blue, the two are indistinguishable morphologically. However, the crucial evidence is that river fish have been tagged and have been recovered as sea fish, having travelled considerable distances in some cases. In any case some fishermen attempt to identify the origin of fish caught on beaches by the amount of "cleaning-up" they have undergone, taking that as a measure of the time they have been at sea and, therefore, of how far they have travelled.

The opinion is held by some fishermen that the coastal rivers and lakes are insufficiently large to hold stocks of fish large enough to make up the travelling schools. However, this opinion surely arises from a misinterpretation of the evidence available to them, and from a neglect of the obvious gaps which exist in their evidence, for as far as is known to the author, there is no accurate method of estimating either the schools seen on the coast or the fish present in the rivers and lakes. Moreover, against this rather negative assumption, there stands the positive evidence of tagging.

Alternative sources of these fish have been suggested, such as New Zealand and other distant islands, or deep oceanic waters, and even a complete round-Australia circuit has been imagined. There is no evidence at all for any of these. There is no report whatever of schools of mullet in offshore waters, either as being sighted on the surface or taken in demersal fishing.

(iii) Methods and Seasons of Fishing:(a) River and Lake Fishery:

The mullet in the rivers, lakes, and large bays may be taken during winter, spring, and summer by means of haul

* Tag C.S.I.R. 1606. See p. 56.

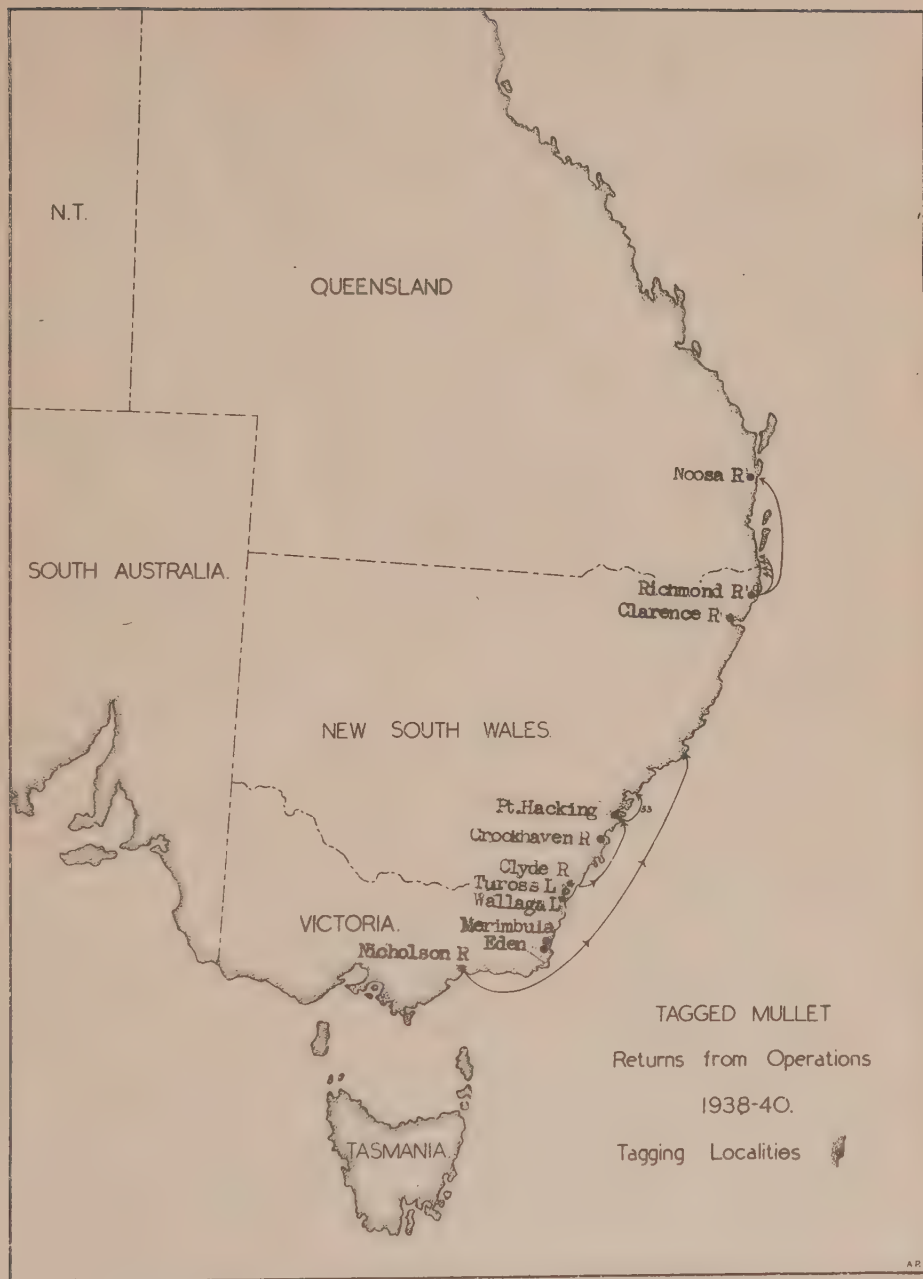


Fig. 2 - Tagging localities and the direct path taken by recovered fish.

seine nets, set nets, and traps.

The mullet of this fishery are variously known as bully-, lake-, river-, hardgut-, and mangrove-mullet. They are immature or recovering and ripening fish; they are generally slimy and brown. Sometimes these fish are empty gutted and slab-sided, these being the hard-gut mullet; mostly they have mud and sand in the gut. The prevailing

sizes are generally smaller than those of the travelling fish; this would appear to be due to the larger fish occupying relatively inaccessible situations so that they do not greatly enter the fishery. The fish are taken chiefly in the fresh and brackish waters; in drought times, when the brackish waters extend further up the streams, the fish are found higher; conversely, floods will drive the fish further down the river system and may even start a migration into the sea. It is reported that during the colder winter months the fish tend to concentrate in deep waters and to move nearer the fresh water.

The nets employed are chiefly haul seine nets consisting of a bunt flanked by wings generally of larger mesh; usually there is a cod-end (or pocket) in the centre. The length and depth of the net and the mesh size are subject to regulations which differ for the various waters*. Some of the lengths allowed are quite considerable and, occasionally, although it is an illegal practice, nets are even joined to provide immense fishing lengths. Winches are often used, even with nets of permissible length; the commonest type of winch is a two-handled manual winch anchored either in the fishing boat or to a tree on shore. These nets are shot in great arcs up to one thousand yards deep, and are then drawn in by the winch, the operation being slow and sometimes occupying four or five hours. The method called "fleeting" may be used; in this method the hauling line is at intervals moved further out along the wings towards the bunt, which is being drawn in. Sometimes a backing net is used. This may be a different net, or simply a portion of the same net already drawn in; its value is in capturing mullet which leap over the bunt.

In Queensland waters a process called "ringing" is used; in this the net is shot in a straight line and one end is fixed upon poles about ten feet in length; the other end is then worked around in a spiral which is gradually reduced in extent. More poles are used as the fishing proceeds. An area of ground is in this way encircled and closed off, and eventually the net at the centre of the spiral is picked up with the fish. In this method the fishermen are operating in water waist high and more.

Mesh nets of various dimensions are permitted in various waters. These are used in different ways. In general the fisherman reconnoitres until he locates a group of fish by their leaping from the water. The net then may be shot in a straight line or a circle, and fixed to an anchorage or left floating. An effort may or may not be made to frighten the fish into the net by splashing. The nets are sometimes left for hours, but sometimes they are cleared almost at once.

A good deal of this fishing is somewhat speculative. The presence of the fish may be assumed by the fisherman upon the basis of his previous experience of the locality or may be inferred from the jumping of a few fish. Profitless shots are, therefore, quite common.

(b) Coastal Fishery:

This fishery operates from sea beaches (and those just within the estuaries and bays) upon the fish engaged in migrating. The major part of the fishery is for the fish migrating to spawn; the minor part is for immature or unripe fish moving at other times of the year than late

* See page 17.

summer and autumn. The fish taken here are generally known as sea-mullet, or possibly hardgut-; the former are distinguished by their clean appearance and bluish colour, they are generally empty-gutted, naturally never earthy as the river fish sometimes are, and nearly always they are advanced in roe; after the middle of the season they are very close to spawning, the males in fact then "running-ripe"; in Queensland a percentage of spent stock occurs in this fishery; finally, these fish are generally the largest of the mullet fishery. Corresponding with the *en échelon* movement of the fish mentioned above, the operations of this fishery are also *en échelon*, commencing in the south at the beginning of the year and ending in the north towards, or even after, the middle of the year.

Seine nets and traps are employed in this fishery, but the bulk of it is conducted with seine-nets similar to, but shorter than those employed in the lake fishery, and thus not requiring the use of winches. The method of operating these nets is as follows: The appearance of the fish working along the beaches and headlands is awaited by a look-out on a hill, cliff, or tree, or even on a specially built look-out tower. The fish are seen as a dark shadow moving through the water, or they may be exposed in the advancing front of a wave. The boat with its net is generally kept waiting on the shore, but when a school approaches it is launched and a boat crew keeps it offshore and works from directions given by the look-out. The look-out signals the boat to move from the shore as the fish draw near to the boat, and men on the beach retain the free end of the net. When the fish approach within range of the net the boat is rapidly rowed outwards, then parallel to the shore (in the direction opposite to that taken by the mullet), and then brought quickly to the beach thus having enclosed the school. Some skill is required in timing the movements of the boat to close in the fish, and in hauling the net so that they do not dive beneath the lead line or jump over the cork line. Difficulties also are met in rough weather in ensuring that the net "fishes" efficiently. The fish, captured in the bunt or cod-end, may be landed on the beach or tipped* out of the net direct into the boat; if the shot is made on a rocky foreshore such tipping becomes a necessity. A recent development on the long hard beaches in the north is the use of old motor lorries and trailers; the boat with the net on board is carried on the trailer: when the fish are sighted the boat is manoeuvred into a good position on the beach and then launched from the trailer. Such equipment facilitates second attempts at schools which manage to evade the first shot; it also permits an easy working of different beaches according to the dictates of the weather; finally it allows the use of the same equipment for beach and for lake fisheries.

Such fishing as that described here is carried on in the season of the travelling mullet when the fish are expected. Their movement appears to be determined by the winds, for they travel, with few exceptions, only when winds are in the south-western quarter. During the season the appearance of these winds is eagerly awaited by the fishermen. Again, as mentioned above, the fish avoid flooded rivers, so that if heavy rains fall while the fishermen are awaiting the travelling fish it is quite possible that they will obtain no catch. Outside of this season, catches of mullet are quite often made by men who operate permanently on the beaches catching whatever may appear.

* The term "tip" indicates the practice of removing the fish collected together in the bunt, either by dipping with a dip-net or with a basket, or by pulling the net over the gunwhale so that the fish are rolled in.

In Queensland, north of Gladstone, wire netting traps fixed on the shore, are used. These consist of wings and a central trap set in an arrowhead plan, with the apex directed seawards and the long axis at right angles to the main line of the beach. These traps are exposed at low tide and captures can then be removed. At high tide the fish, moving along the shore, encounter the wing and follow it outwards, this directs them into the trap, from which they cannot escape. In addition a further quantity of fish is caught against the netting of the wings when these prevent them following the receding tide down the beach. Difficulties are experienced from sea-gulls and similar birds when the trap is exposed, and sometimes from the inadvertent capture of sharks or even porpoises. Traps such as these are not permitted in New South Wales, but pens within which to hold fish may be constructed, permission being obtained for the use of the site chosen.

(iv) Marketing:

Mullet hold an assured place in Australian markets. They are highly edible, fresh or smoked. As fresh fish they figure importantly in all markets, but most importantly in Brisbane. There is also a large local sale in coastal towns and also to tableland and inland towns. In Queensland, north of Maryborough, there is prejudice against them, and they cannot be sold (as mullet) in Bundaberg, Rockhampton, or the other northern towns. As fresh fish, mullet is important to the fried-fish shops and to restaurants. A large quantity is smoked in almost all centres. The roe carried during the travelling season is sought for sale fresh and also smoked; large quantities are exported, especially to Egypt.

By far the greatest proportion of the catch is sold in the metropolitan markets to which the fish are sent by rail or by motor-lorry. The latter method is used extensively during the glut seasons. The fish are generally packed in wooden boxes with crushed ice in alternate layers. This practice has been in use for many years (see New South Wales Fisheries Report 1903). Where possible, fishing is done at times to meet the transport timetable: the fish are caught and fetched to a packing wharf or shed where they are iced and left to be collected by the transport. Sometimes care is not taken, or it is impossible so to adjust affairs, and the fish may have to stay for some hours in the boat, often quite unprotected from the sun. This type of carelessness and also neglect in packing, are at times responsible for considerable losses.

The cost of this marketing procedure can exceed 10/- per case of 70 lb. To the men on the Clarence River the cost per box of sending fish to the Sydney Market is estimated at 9/1d., consisting of ice 1/-, packing, wire, etc. 1d., freight to railway 1/-, freight on railway 5/-, hire of box 6d., freight railway to market 1/-, market due 6d. To this is to be added 10 per cent. commission and sometimes ice-house charges of about 4d. This cost is high but in some instances it is still higher; however, generally it is this or lower. The marketing costs in Brisbane have been definitely lowered.

Mullet is sold at from 20/- to 30/- per box during winter and spring, but during the glut season the price often falls to below 10/-. When it is remembered that the

roe can be more than 10 per cent. of the weight of fish in this season, fetching up to 10d. per pound, and that, moreover, it is not difficult to set the flesh down in refrigerators or to have it smoked, it will be appreciated that there exists here considerable mismanagement calling for action on behalf not only of fishermen but also of consumers. The problem of these glut periods was remarked upon by Lindsey, Thompson, and Dick (1934) who stated - "Past experience shows that a reduction in the price of sea mullet to a minimum, during glut periods, in order to stimulate a demand for the surplus supplies, results in the sale of only a limited quantity of fish." The situation is clearly one calling for action on the part of fishermen.

(v) Existing Control.

It cannot be said that the responsible authorities have been unaware in the past, or are still unaware, of the need for restrictions upon the activities of fishermen; and it cannot be said that nothing has been done by them. However, in the absence of accurate information upon the biology of the fish which they wish to protect, or upon the methods of the fishery which they propose to manage, it is very unlikely that adequate and correct measures could be taken. An examination of existing control measures which operate upon the mullet fishery* shows that these measures are not consistent and do not seem to be based upon any policy directly related to the biology of the fish. In a later section evidence will be presented to show that whatever principles may have guided the authorities concerned in devising their control, the present condition of the fishery indicates that the system is inadequate.

Control measures relate to the size of nets, the closure of certain waters, restrictions on methods of fishing, and limitations on the lower limits of sizes of fish to be caught. An attempt is made here to summarise these measures:-

(a) Haul (Seine) Netting:

Considerable attention has been paid to this method of fishing, for it is the principal mode of capturing mullet. The allowable lengths of net and the maximum mesh size are set out in Table 1A. It will be seen that in the southern States (excluding, that is, N.S.W. and Queensland) the specifications as to allowable length, bunt size, etc. are in general somewhat incomplete; also the mesh sizes are for the most part much smaller than in the other two States. In New South Wales the various nets numbered (a) to (q) are those allowed in different waters; a similar practice of stipulating different nets exists in Queensland and in other States, but to a lesser extent. These variations are made, it is assumed, upon the basis of estimates of the amount of ground available to the fish for escape and of a kind of ratio between net size and area of fishing water. But it is fairly certain that the actual determination of allowable length of net consists of adjusting the length upwards to a point which the fishermen assert (or show) to be sufficient to secure from the waters under examination a quantity of fish which is held to be an adequate return for labour expended. However, where the fishery is in a condition that its stocks are gradually diminishing, then every successive trial that the authorities are prevailed upon to make will show that a greater length is necessary to secure that quantity, and the effect of the increased

* See Table 1.

permissible length will obviously be to increase the fishing intensity and to hasten diminution of stocks. Consequently allowable length should be decided by accurate estimates of the efficiency of the nets, the "fishability" of the waters, and the condition of the stocks.

On the other hand the question of minimum allowable mesh is still a sorely debated one, whereas it could surely be determined by a series of well controlled experiments. No agreement seems to exist as to what sizes of fish are captured by the various meshes. The table shows that meshes from $1\frac{3}{4}$ inches to $3\frac{1}{2}$ inches are usable in fishing operations which may catch mullet. Although part of this series is due to the differences in the minimum legal lengths,* and as in the case at least of Victoria, to the fact that *M. dobula* does not figure very greatly in the catches of some States whilst *A. forsteri* (which is a smaller fish) does, nevertheless there remains the anomaly between Queensland and New South Wales, that whilst the latter has a legal minimum of 12 inches and most of the nets have bunt mesh 2 inches and wing mesh 3 inches, in Queensland where the legal minima are 11 inches and 12 inches, the corresponding meshes are $2\frac{3}{4}$ inches and 3 inches and $3\frac{1}{2}$ inches. This is clearly a case of difference of opinion on the effectiveness of the respective meshes and is an obvious matter for adjustment by experiment.

(b) Set (Mesh) Nets:

The allowable set nets are shown in Table 1B. Much the same situation exists in respect of these as does for the haul nets, i.e. there are differences for which there are no obvious explanations and which imply, for the sake of efficient administration, the urgent need for experiment by which to place this type of control measure upon a sound basis.

(c) Traps, etc:

Victoria: Paddocking is, in general terms, prohibited in this State.

New South Wales: Fish traps 5 ft. x 3 ft. x 3 ft. of mesh $2\frac{1}{2}$ inches on top and 1 inch below, may be set, provided that they are marked and identified; a licensed fisherman is allowed to have five traps, other people may have only two.

Queensland: Large traps for use on the coast are permitted. Traps may be up to 700 yards in length, and 10 ft. in height, with mesh not less than 4 sq. inches in area; the trap must be licensed and identified and may not be placed in a tidal river or stream, within half a mile of another such trap, or below low tide mark. Traps must be kept clean and the fish must be removed once at least in every 48 hours.

These methods of fishing are not important, and are mentioned here only to indicate the range of allowable fishing methods.

(d) Methods of Using Nets:

Length of hauling lines is limited in some waters in New South Wales. The relaying of hauling lines is prohibited in New South Wales waters. Joining nets: nets of maximum permissible size may not be joined together. The use of nets in such a manner as to obtain a smaller effective mesh than is permitted, is prohibited. These prohibitions are operative

* See page 19.

in most States except that some joining of nets is permitted in Queensland in Moreton Bay. Emptying nets: in all States nets must be emptied in such a manner as to permit the escape alive of under-sized fish.

(e) Closure of Waters against Nettings:

There is, throughout Australia, a complex system of partial and complete closures of coastal waters against various types of fishing operations. Some closures are for part of the year, some are regular weekly closures, some are permanent whole-year closures. So far as can be determined none of the partial closures have reference to the travelling phase of mullet, nor does it appear that there is any reference especially to the disperse phase. Regular weekly closures are commonest in Victoria; it is difficult to say whether these are anything more than merely a lip-service, since most fishermen take some days relief from their work in each week, and such week-end closures as these could possibly have no more effect than to standardise such relief. On the other hand partial and regular closures can be rendered useless by an increase in fishing intensity in open periods. Permanent closures are chosen either to protect spawning grounds, nursery grounds, feeding grounds, or areas of greatest susceptibility: when, however, it is realised that very little at all is known about spawning, feeding, or nursery grounds, and that there is no agreement whatsoever as to in which areas the mullet are most susceptible to fishing, it will be understood that some at least of these closures must be of doubtful value. In the argument which exists between those men who operate on the coast and those who fish the lakes and rivers, each group asserts that the other is removing mullet when it should be most protected. The beach fishermen consider that no fishing should be done upon the fish when they are in the lakes and rivers since they are then feeding and growing; the other men say that the beach fishermen remove spawning stock which, because they are in schools, are most easily caught. It is possible for both sides to be quite correct and the problem then is to prevail upon them to share, as equitably as possible, the responsibility of effective control*.

In Victoria the practice is to close small streams and also an area of the bay or sea into which they flow around and near to the mouth of the stream. In New South Wales the practice is to close entrances to lakes and small streams; but few closures exist of beaches near to or within the major estuaries such as Clarence River or Hawkesbury River, and it seems that no effective restriction exists to prevent the capture of the travelling fish. Similarly there are closures within the major rivers and lakes but such closures as do exist could not be greatly effective in reducing fishing intensity. In Queensland a firmer stand has been taken with more comprehensive closure of some of the streams occupied by the mullet and prohibition of fishing on beaches near to the river mouths (such as the mullet season closure at Noosa Heads). However room exists here too for improvement.

(f) Minimum Legal Lengths:

Western Australia	-	10½ inches
South Australia	-	7 "
Victoria	-	10 "

* See pp. 83-84 and pp. 88-89.

New South Wales	- 12 inches	
Queensland	- 11 "	1st Aug. - 31st Jan.
	- 12 "	1st Feb. - 31st July

It is clear that such a range of minimum legal lengths is incompatible with the purpose of such a restriction in relation to the biology of the fish. A legal minimum in general is imposed in order to ensure that a certain group of fish is given the opportunity to attain a certain size before becoming subject to fishing operations: such protection being either to ensure spawning or to ensure the attainment of the most profitable weight-length relation. The first requirement then is the accurate determination of the purpose for which the restriction is to be imposed and then of the limits of the group which is selected for protection. By limits is meant the range in size, the rate of growth, and the time at which the fish no longer requires protection. When these facts are available then the legal minimum is set on the upper side of the mean length of the group to be protected: it would be allowable to have a shifting minimum which would increase during the year with the growth of the fish, the advantage being that protection would be maintained after the purpose for which the protection is intended has been accomplished (in most cases securing the spawning of the fish). Practical problems in administration probably make such an arrangement impossible, but a compromise can be effected, as has been done in Queensland, where one legal minimum prevails during the sea-mullet six months' season, and another for the remainder of the year. The condition of the fishery suggests that some very active steps should be taken by which to secure some recovery of the stocks, and evidence is presented later upon the group requiring protection and the rate at which it grows, etc., so that a double minimum, at a higher level, may be agreed upon.

3. BIOLOGY.

(i) Methods, Collection of Samples, etc:

Use is being made of some measurements made by H. C. Dannevig in 1903 (Table 2A). These measurements were published (1903a) as a spot diagram of length frequency for thirty three samples; they have been converted to length frequency tables. The data afford a little help in assessing the present condition of the fishery. Dannevig apparently also weighed the fish of his samples: he published a weight-length diagram and table but, unfortunately, the observed weights as such are not given, but only the mean weight at each length without any indication of the number of fish represented in each mean. The samples were all collected in New South Wales.

In the present investigations, which began at the end of 1937, samples have been collected from many places on the east coast and from some places on the Western Australian coast. Some samples were collected in the course of experimental operations, others in the course of tagging experiments; the bulk of the samples was drawn from the markets in Sydney, Brisbane, and Perth.

1937-38 Samples (Table 2B): in these samples, which were principally from Sydney Market, total length to the tail tip was measured, and also total weight; scales were taken from many of the samples. Length to the base of the pectoral fin, to the anterior edge of the base of the first dorsal, to the base of the pelvic, all three from the snout (see Plate 1), and also inter-orbital and maximum widths, were measured. In addition to whole weight, gutted weight was sometimes taken, and the weight of the gonad was taken where it was large enough to be weighed on the balance available. This work was done when the author was in the employ of the New South Wales State Fisheries. The lengths were measured between parallels of which the anterior line was the snout tip, and the others as indicated by their names. A proper measuring board was not available, and, except for total length, most measurements were merely sighted. The inter-orbital and maximum widths were measured by means of engineers' spring dividers; the former was measured at the inter-orbital ridges above the eye, the latter was determined by trial. All measurements were made to the nearest millimetre above.

Weights were taken with a spring balance, and are slightly suspect. Weights were taken to the nearest quarter ounce. The gutted weight is the weight after the removal of the viscera within the abdominal cavity: the gills were not removed. Except during tagging operations all fish were opened to determine sex and condition.

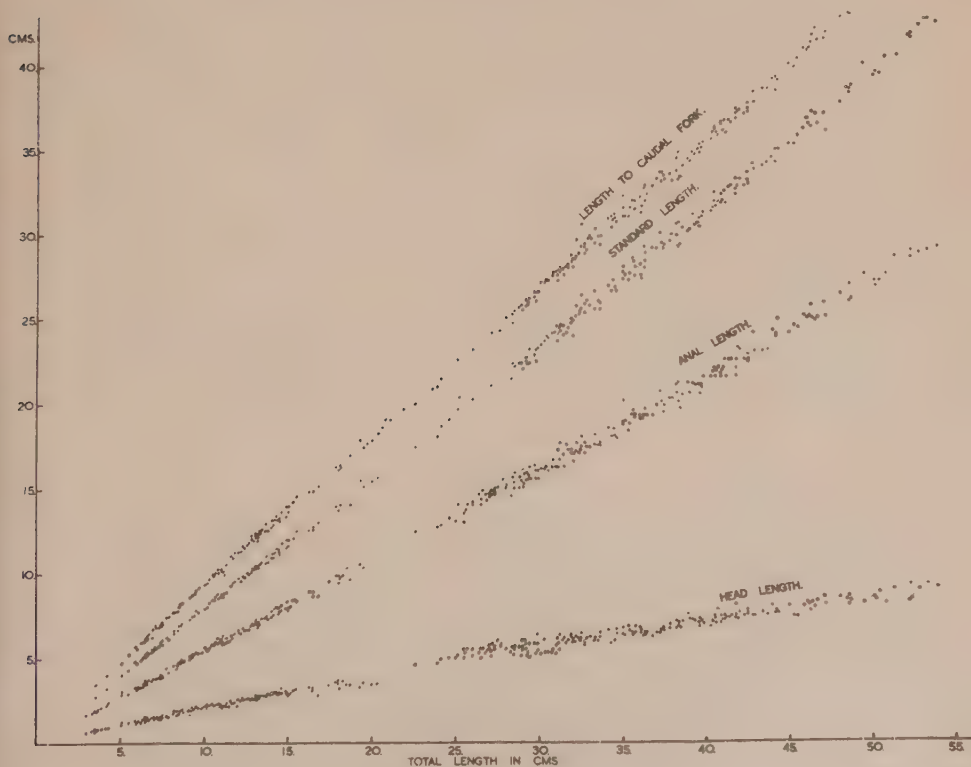


Fig. 3 - The relation between total lengths and various proportional measurements.

1939 Data (Table 2C): A slightly different procedure was adopted during this year. Head length and anal length were taken instead of the previous measurements to the anterior fins. Head length was measured as the length between snout tip and the posterior margin of the operculum; anal length was measured between snout tip and the centre of the vent. Weights were taken with a beam balance and are more accurate than those of the previous year. In certain cases, later in the year, where samples were obviously homogeneous and of the one age-group, all fish were weighed together.

1940 Data (Table 2D): In addition to the procedure employed during 1939, use was made of the celluloid strip method of securing large samples of length measurement; this method is described by Buchanan-Wollaston (1928), modified as described by Colefax (1931); by this method measurements were made to the caudal fork, and these were converted into total length measurements by use of Fig. 3. During this year in particular, sampling was sometimes proceeding at a number of points at the same time, and, therefore, it became necessary to number the samples in different series. A strong effort was made in this year to secure samples of the smaller age groups, and quite a number were obtained from many places along the coast.

1941 Data (Table 2E): During this year the methods of 1940 were continued but, in particular, market measuring was considerably extended by the appointment of a market measurer full time by the New South Wales State Fisheries, and a field assistant full time by Western Australia. These workers were able to measure large numbers of fish.

Western Australian Data 1939-40-41 (Table 2F): The material collected in Western Australia consists of samples obtained in market and in the course of special field operations. The bulk of it consists of length measurements with some sub-sampling for scales and gonad-condition.

Eggs and Larvae: An effort has been made every year to discover the exact spawning place, time, and habit, and to secure developing eggs and larvae in plankton catches. The efforts were made at Port Hacking in 1937, 1939, 1940, Clarence River 1937, 1938, 1939, Richmond River 1938, 1939, and Tewantin 1940 and 1941.

(ii) Species:

The family *Mugilidae* is represented in the commercial fisheries of Australia by the following species, placed approximately in their order of importance: *Mugil dobula* (sea mullet), *Agonostomus forsteri* (yellow-eyed mullet), *Lisa argentea* (flat-tailed mullet), *Myxus elongatus* (sand mullet), and *Ellocheilus vaigiensis* (diamond-scaled mullet). The approximate distribution of these species is shown in Fig. 1. In addition to the five species listed here, McCulloch (1929-30) names 24 other mullets.

The species *Mugil dobula* is the main subject of this paper. Hitherto the fish of this species have been known as *M. cephalus** and were listed under that name by McCulloch. However, the mullet of this coast cannot be identified with Linnaeus' description of *M. cephalus*, and it is possible

* *M. dobula* was used by N.S.W. State Fisheries in a regulation as to minimum legal length in 1939. The authority for the change was not cited.

that no specimens could be fitted to that description which appears to contain actually two species at least. His description* was as follows:-

"Mugil. Caput: Labia membranacea: inferius introrsum carinatum.

Dentes nulli; Denticulus inflexus supra sinus oris.

Membrana branchiostega radiis septem curvis; opercula laevia, rotundata.

Corpus albicans.

Cephalus 1. M. pinna dorsali anteriore quinquerradiata.

Mus. Ad. Fr.2. p.104. D.5, 1/9. P.16. V.1/6.

A.3/12. C.12.

Art. gen. 32. syn. 52. spec. 71. Mugil. D.5, 1/11.

P.18. V.1/6. A.3/13. C.--

Hasselqv. iter. 385. Mugil cephalus D.5, 11. P.13.

V.6. A.10. C.--

Habitat in Oceano Europaeo, Fluvios subiens.

Botargo italorum ex hujus ovis."

The fin-ray formula for Australian species which has been known as *M. cephalus* is D.IV+ I+8, P.16-18, V. V, A. III+8, C. 12-14

The important differences are in the dorsal and anal fins. *M. cephalus* therefore is unacceptable for the present species, and the first acceptable description being Gunther's account of *M. dobula* that name may be used for this species. Gunther's specimens were from Western Australia, but since the eastern Australian stock does not differ in any significant way from the Western Australian the description and name may be taken to apply here.

There is a bulky synonymy of common names for *M. dobula* in Australia. It is known as sea mullet in all states, and as poddy-mullet in W.A., sand-mullet in Tasmania, sand and also poddy-mullet in Victoria, mangrove-mullet in Queensland, and as bully-, bullhead-, hardgut-, river-, and lake-mullet in New South Wales. Mangrove and hardgut are almost certainly equivalent terms referring to immature fish, and possibly the alternative terminology in other States has similar significance, except that poddy-mullet in Victoria signifies the mature fish.

(iii) Raciation:

Reference has been made to the distinction made by fishermen between those fish which they describe as "sea" fish and those they describe as "river" fish: evidence† is available to show that these two groups and the "hardgut" fish are simply different life phases of the same fish. Nevertheless the possibility existed that the three areas occupied by mullet, i.e. the western, southern, and eastern Australian coasts, held distinct stocks. As stated above, the fish of the west and of the east were found to be of the same species, but the possibility remained that there were separate races in these areas. Moreover it is possible that the eastern coast supports two or more races. Since such races, if they existed, might require some differential form of management it was necessary to examine these possibilities.

* Linnaeus (1766).

† See Section 2(i) and Section 3(ix).

(a) Evidence from Movements:

There is no evidence from fishermen's observations or from any other reports that there is any exchange between the populations of western and south Australia nor between south and eastern Australia. In the light of other evidence accumulated here in respect of the grounds occupied by mullet, of their need to have access to brackish coastal waters, and of their habit of moving in schools on their spawning migration, it does not seem feasible that there should be exchange between the west and the south across the wide stretch of the Australian Bight unrelieved as that is by coastal brackish waters of any sort. The possibility of exchange between south and east still remains, but nevertheless the absence of reports of travelling mullet in the region between Port Phillip and the Coorong and the rarity of catches of mullet in this region suggest that there is no mixing here either. Until further evidence is available, preferably following more tagging operations, it may be assumed that these three populations are distinct.

On the eastern coast, tagging experiments have confirmed opinions based upon observation that there are extensive movements of the mullet. The nature and extent of these movements is discussed in a later section where it is shown that a considerable overlapping movement of the fish proceeds northwards in the course at least of the spawning migration - if not at some other time as well. While these movements in the present connection may be interpreted only in relation to what may be shown to be their biological significance in respect of spawning, nevertheless they provide *a priori* grounds for supposing that there are no separate stocks on this coast. In the absence of definite information upon spawning it is still possible to suggest that mechanisms exist to maintain the isolation of definite races in spite of their occupation of the same area. The problem, therefore, has to be approached from other angles.

(b) Morphological Characters:

A. Meristic: These characters, including fin-ray counts and vertebral counts, which have been used extensively in certain fisheries studies, have here proved rather useless. A full account may be given of the work done in the present study.

(1) Fin-ray counts: These show little variation and it may be accepted that, in respect of these features, mullet are quite stable. The rays of the anal fin are diagnostic: the count III+8 distinguishes *M. dobula* from almost all other mullet of Australia. The hard-rayed dorsal and the ventral fin are quite invariable and the soft-rayed dorsal shows no significant variation. The pectoral and the caudal fins have shown some variation in the records of counts made, but since there is some difficulty in establishing the number of some of the last smaller rays the differences which occur, and which in any case are small, are probably in the nature of error variance. The variance in the samples examined has been so small that to demonstrate a significant difference would require the treatment of samples of quite unwieldy proportions.

(2) Vertebrae: The vertebrae may be represented in the following formula: $n = 24$ consisting of (11+13) (1+1+1+6+2) + (10+1+1+1). So far no fish has been examined which had anything but 24 vertebrae. The separation of the total number of vertebrae into groups

has been done following Ford (1937). The first grouping is into pre-caudal and caudal units; of the pre-caudal vertebrae there are five types and of the caudal there are four types. The character of each of these types is as follows:-

Pre-caudal I - Broad flattened neural crest extending forwards and overlying the posterior end of the skull, cleft to receive the somewhat extended supra-occipital crest; horizontal lateral process with sharp anterior edge, rounded posterior edge; nerve foramen at base of lateral process; posterior articular surface articulating with anterior lateral process of the vertebra following; a double ridge on ventral surface of centrum.

Pre-caudal II - Broad flattened neural crest articulating with neural crest of P-c I; lateral process narrow arising from anterior dorsal edge of centrum, deeply gouged so that the process is V-shaped in section, lies at angle of 45° to the horizontal plane of the vertebral column; a small flattened posterior articular surface articulating over part only of the length of the anterior lateral process of the vertebra following; strong double ridge on ventral surface.

Pre-caudal III - Neural crest flattened but not as broad as the crest of the preceding vertebrae; anterior lateral process quite broad inclined at slightly steeper angle; no posterior lateral process; double ridge on ventral surface of centrum.

Pre-caudal IV - Six vertebrae. Neural spine divided into anterior and posterior parts, of which both are flat and expanded in first two of this group, but only the anterior part flattened in the posterior four, the posterior part in these latter is then merely a neural spine; the anterior neural process approximates to the spine of the preceding vertebra; the thin neural spines occupy a position near to the centre of the vertebra; there is a fenestra in the dorsal surface of the neural arch between the anterior and posterior parts of the neural spine. Dorsal post-zygapophyses, arched strongly backwards, are present; the lateral processes are progressively shorter and more vertical in direction; posterior edge of the lateral processes is continuous by a ridge across the lateral surface of the centrum with the posterior neural processes; the anterior edge of the lateral processes is grooved; spines, which appear to be incipient ventral post-zygapophyses may be present on the last three of these vertebrae; ridge on ventral surface is single on the first five, absent from the last.

Pre-caudal V - Two vertebrae. Anterior neural spine small, hooked; posterior neural spine tall and grooved; well developed dorsal and ventral pre-zygapophyses; lateral processes vertical and joined ventrally to form haemal arches; ventral pre-zygapophysis present on the second.

Caudal I - Ten vertebrae. Haemal spine present and also ventral pre-zygapophyses, in addition to the characters of P-c V; neural spines are progressively smaller.

Caudal II - Neural and haemal spines involved in the tail complex.

Caudal III - Neural spine considerably reduced in length.

Epurals: two epurals are associated with the neural spine of the vertebra lying just above it with their anterior end in front of the tip of this spine. The anterior epural is slender and pointed, the posterior is flattened. The haemal spine is flattened somewhat and supports caudal raylets.

Caudal IV - Urostyle: Centrum is smoother than the centra of other vertebrae; it bears, on both sides, a backwardly directed hook-like process. Hypurals: four in number (representing 6 larval elements according to Hollister (1927)); the first and fourth are narrow while the second and third (which are said to be fused pairs) are somewhat broad and fan-shaped. The third bears a number of grooves. Uroneural: a narrow bar lying adjacent to, and in front of, the fourth hypural.

The surface of all vertebrae is considerably reticulated.

Among specimens of *M. dobula* there are no departures from the general formula and small variations only from the general characters described above. Such small variations are chiefly in the shape of processes etc. and are individual rather than racial. It is possible that work on other skeletal parts may reveal characters whose variation may be diagnostic of races. Even in other species there is the same total number and the same pre-caudal and caudal portions. Differences occur in the number of "crested" vertebrae, in the shape of neural crests and lateral processes, and in degree of reticulation of the surface.

(3) Scales: The scales of the lateral line, counted from the first scale behind the pectoral axillary scale to the caudal flexure are thirty-eight in number; the small scales behind the flexure are three or four in number. As in the case of fin-ray counts and vertebrae, there is insufficient variation to warrant use in racial determinations. The head scales are irregular in shape and in the pattern of disposition, the foremost ones are very small and the middle ones are very large; there are about eighteen but it is very difficult to establish a standard procedure by which to count them.

There are fifteen rows of scales, counting obliquely across the flank from the anterior edge of the first dorsal.

In precise work upon scales, as is employed later in relation to age determination, the following system of enumeration is used. The rows are numbered in roman and the scales in the rows are numbered in arabic. Scale VII-1 is taken as a datum point; this scale lies beneath the tip of the axillary scale level with the dorsal edge of the pectoral base. The validity of identifying this row as VII is established by counting the clearly identifiable rows from the mid-dorsal row lying between the dorsal fins. The commencement of the other rows is determined by counting obliquely from VII-1, cephalad below and caudad above; XV-1 thus lies immediately above the base of the ventral. III-1 is easily identifiable; row II however commences at number 6, which is adjacent to III-6; row I commences at number 19, lying adjacent to II-19 and at the posterior end of the first dorsal fin; no scales in front of II-6 or I-19 lie in direct line with the

true row, and actually the linear series defined thus from the datum point of VII-1 includes the whole of the regular scalation of the flanks, and excludes the irregular areas found on the head, the tail, and ventrally in front of the ventral fin. Again, the system gives uniformity to the identification of the relationship of fin position and scale number, a systematic method employed for mullet by Jacot (1920) and others. The correspondence is thus: D1 lies at 12, D2 at 24, V at 1, and A at 16.

B. Body Proportions: Various measurements have been taken of body proportions of fish taken in a fairly wide range of samples. These measurements are described in Section 3(i) and some of them are shown in Plate 1. The regression of each measurement on total length is shown graphically in Fig. 3; the relevant correlation and regression coefficients are given in the table below.

The Relation of Various Proportional Length Measurements to the Total Length

Proportional Measurement	No. of Fish	Length Range	Regression Equation	Corr. Coeff.
Head Length	1129	3-58 cm.	$y = 0.172x + 0.216$	0.99
Pectoral Length	395	25-46 cm.	$y = 0.163x + 0.69$	0.65
Pelvic Length	396	25-46 cm.	$y = 0.290x - 0.18$	0.89
Dorsal Length	392	25-46 cm.	$y = 0.396x - 0.41$	0.95
Anal Length	1081	3-58 cm.	$y = 0.551x - 0.073$	1.00
Standard Length	611	3-57 cm.	$y = 0.784x + 0.046$	1.00
Length to Caudal Fork	758	4-53 cm.	$y = 0.866x + 0.735$	0.99
Snout Breadth	365	25-46 cm.	$y = 0.131x + 0.01$	0.89
Maximum Breadth	383	25-46 cm.	$y = 0.255x - 1.90$	0.87

(x in all cases is the total length, y in each case is the respective proportional measurement.)

It will be seen from this table that there is a close correlation between each of the proportional measurements and total length; the correlation is closest where the raw data are of greatest bulk and the range of length is widest. The closeness of the correlation is taken to indicate a general homogeneity in the population from which the raw data for these calculations were drawn; the data for the Pectoral, Pelvic and Dorsal Lengths, and for Snout Breadth and Maximum were drawn from the samples listed in Table 2B, and the data for Head, Anal, and Standard Length and for Length to the Caudal Fork were drawn from the samples in Tables 2C and 2D (A); it is thought that these samples are drawn from sufficiently varied localities to justify the assumption that the mullet stock of Eastern Australia is homogeneous. It has been the practice in racial investigations of this type to make use of the method of indices by which the various proportional measurements are expressed as fractions of total length, and the mean of such fractions

for each sample is compared with the means of other samples. This method has been followed in the present work and the results are shown in Table 3. The indices employed are Head length, Trunk length, and Caudal length as percentages of total length; Head length is a direct measurement, Trunk length is the difference between Anal length and Head length, and Caudal length is the difference between Anal length and Total length. Table 3A gives these indices for O and I group fish; for the most part there is a uniformity about the results and such wide variations as occur cannot be fitted into any concept of distribution of races. These indices for immature fish, particularly Head and Trunk length indices, differ somewhat from the indices of older fish shown in Table 3B; since the caudal length index of the immature fish does not greatly differ from that of the older fish, it is assumed that the differences in the other two indices arise mainly from a change in the relative size of the head length. This difference (in relative size of the head) did not appear in the regression equation but it is discernible slightly in Fig. 3; moreover, a change in relative size of head is characteristic in immature stages of fish. The indices given in Table 3B show such a degree of consistency that no grouping according to origin, time of sampling, or length could provide evidence of raciation. It is clear therefore that these measurements indicate the homogeneity of the mullet stocks.

At the commencement of the investigation (during 1937-38) measurements were taken of head length, length to the base of the pectoral fin, to the base of the first dorsal, and to the base of the ventral, width of the head was measured, and maximum depth. These measurements, overall, show the same constancy, and the general results (for lengths to fins) are summarised in Table 3C. Although there is a significant difference between the first and the last measurements, since most of the samples are from the same locality and since also there is reason to suspect variation in the measuring technique, no importance is attached to these results from the point of view of racial investigations. The Table is included in order to show the proportions that these lengths are.

(c) Physiological Characters:

(1) Spawning Time: See Sub-section (vii) below for an account of spawning; it is shown there that further information is yet needed to complete this account. It is not yet known whether spawning occurs over a wide, continuous area, or is restricted to one area in the north, or might occur in a number of small but widely separated areas. Unfortunately tagging results still leave a gap between the movements in the south and those in the north, so that no information is yet available of movements in the vicinity of Port Macquarie.* Yet even if this were available the possibility would still remain that the south and north coasts are distinct spawning areas in which, from other information, it would be possible to say that the spawning times differed. It may be said, however, that the general indications do not seem to support this.

(2) Growth Rates: See Sub-section (v) below; at present no races are separable on the basis of growth rates.

(3) Condition Factor: See Sub-section (iv) below. It is possible that studies here will serve to differentiate parts of the eastern Australian stocks but not to establish races.

* Since the above was written, C.2515, which was released at Port Hacking, has been recovered at Carden Haven.

(d) The Probability of Homogeneity:

So far no method has been devised for establishing racial differences between the stocks of mullet (*M. dobula*) in Australia. It seems probable that whilst the stocks of western, southern, and eastern Australia are indistinguishable on any morphological grounds, they nevertheless remain distinct simply because of spatial separation which is not overcome by migration or drifting of eggs or larvae.

On the east coast there is continuous movement from the southern rivers into those north of them and, as indicated in other sections, there must be recruitment from the northern rivers into those south of them, although the evidence to show when this happens is yet wanting. Because of this, and an inability to separate races on any justifiable grounds, it is felt that there is one continuous intermingling stock on the east coast. The consequence of this to any approach to administrative work is great, for it will be quite clear that all three States, as well as both phases of the fishery (lake and beach), operate upon the one stock, and that eventually the removals even by Victorian fishermen could affect the yield obtained by New South Wales fishermen. That is, the problem is one for a single uniform policy.

(iv) Weight-length Relation, Condition Factor, etc:

In general, the weight of a fish increases as an exponential function of its length, as can be seen from Fig. 4, where for *Mugil dobula* the mean weight at each centimetre is plotted against length. For *Mugil dobula* the relationship is approximately $W = 0.01L^3$, where the weight is in grammes and the length is in centimetres. This is a straight line relationship (see Fig. 5) for lengths up to 40 cm., but for greater lengths, although there is an approximate straight line there is a slight change of direction; this difference in these older fish probably has an explanation in the inadequacy and special selection of the sampling of these groups which are represented almost wholly as spawning fish.

Although the curve for mean values (Fig. 4) is very smooth there is considerable variation; this variation arises out of differences in the bulk and weight of visceral and of somatic tissues. Of the viscera, the gonads, mesenteric fat, and alimentary canal may vary greatly in weight, absolutely and also relatively to one another and to the somatic tissues. To a certain extent these changes are reciprocal, that is, the gonad makes its increase partly, at least, at the expense of the viscera, fat deposits, and the somatic tissues, for of these the fat deposits disappear once the gonads approach maturation and the alimentary canal becomes reduced to a small knot of tissue when the gonads are mature. This is shown to some extent in Table 4B. It will be seen that the gut is roughly 10 per cent. of the total weight of the fish, but in ripe fish, about to spawn, the gut is 3 per cent. or less; again, the gutted weight which in unripe fish is roughly 90 per cent. falls to nearly 81 per cent. when the fish are ripe; fat deposits may become as much as 2 per cent. of total weight; gonads, on the other hand, may become as much as 20 per cent. of the total weight. Although these figures suggest that the gonad is developed at the expense of other viscera and of somatic tissues, this is by no means a certain conclusion from such percentage figures, for it would be possible for the one organ to increase in

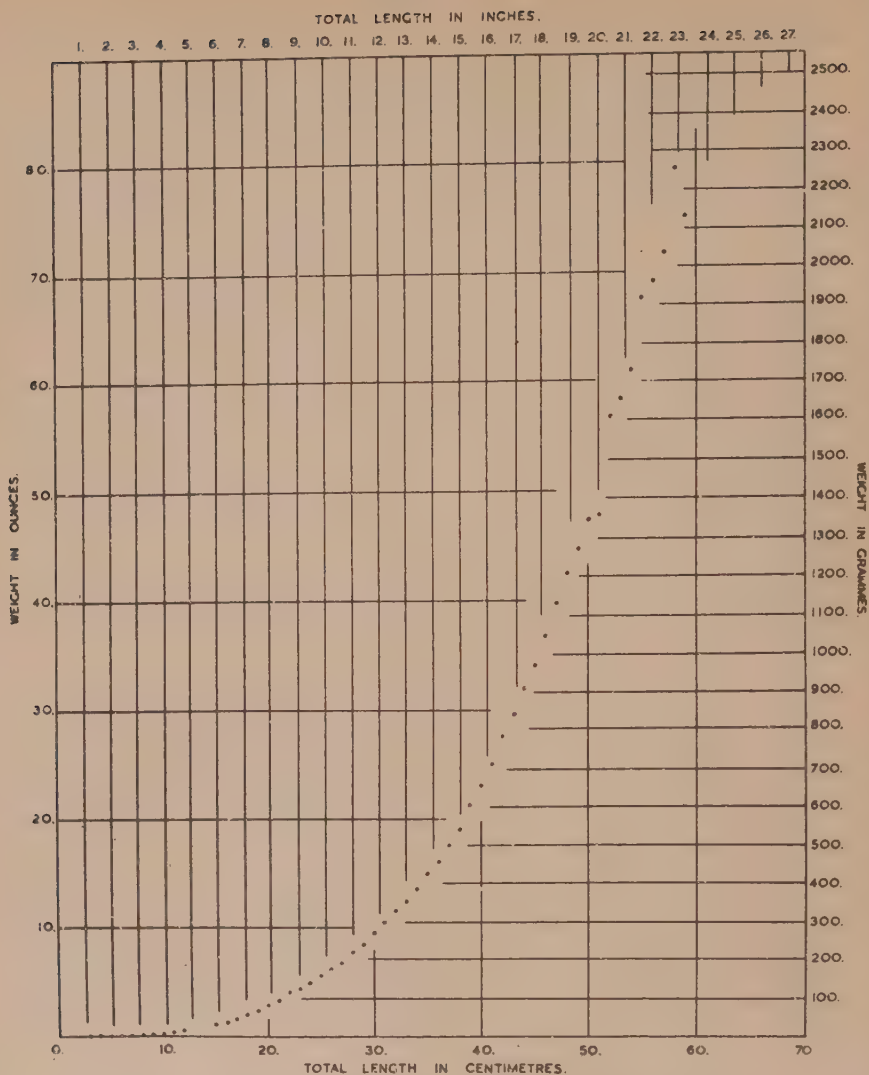


Fig. 4 - The weight-length relation in *M. dobula*.

bulk, from outside material, so that the proportion which each other organ would be of the new total weight would be less than its proportion of the old. This possibility can be tested by use of the "condition factor" (for which see below) and by use of direct comparisons of weights as in the table below:-

Length cm.	Mean Whole Wgt. g/cm.	No.	IMMATURE FISH:			RIPE FISH:				
			Whole Wgt. g/cm.	Gutted Wgt. g/cm.	Gut Wgt. g/cm.	No.	Whole Wgt. g/cm.	Gutted Wgt. g/cm.	Gut Wgt. g/cm.	Gonad g/cm.
35	12.08	2	12.78	11.55	1.42	2	15.05	13.56	1.18	0.51
36	12.82	-	-	-	-	-	-	-	-	-
37	13.60	1	9.75	8.95	0.70	3	14.91	13.21	0.74	0.94
38	14.23	2	14.70	13.60	1.08	4	14.23	13.15	0.50	0.99
39	15.50	1	14.20	12.70	1.48	9	15.34	13.66	0.65	0.99
40	16.42	1	16.30	14.50	1.70	7	15.90	13.95	0.82	1.11
41	17.42	1	14.72	13.70	1.03	10	17.66	15.65	0.71	1.28
42	18.75	2	18.60	16.90	1.75	10	17.12	15.48	0.74	1.28
43	19.70	2	20.11	19.60	1.50	5	19.31	17.07	0.94	1.33

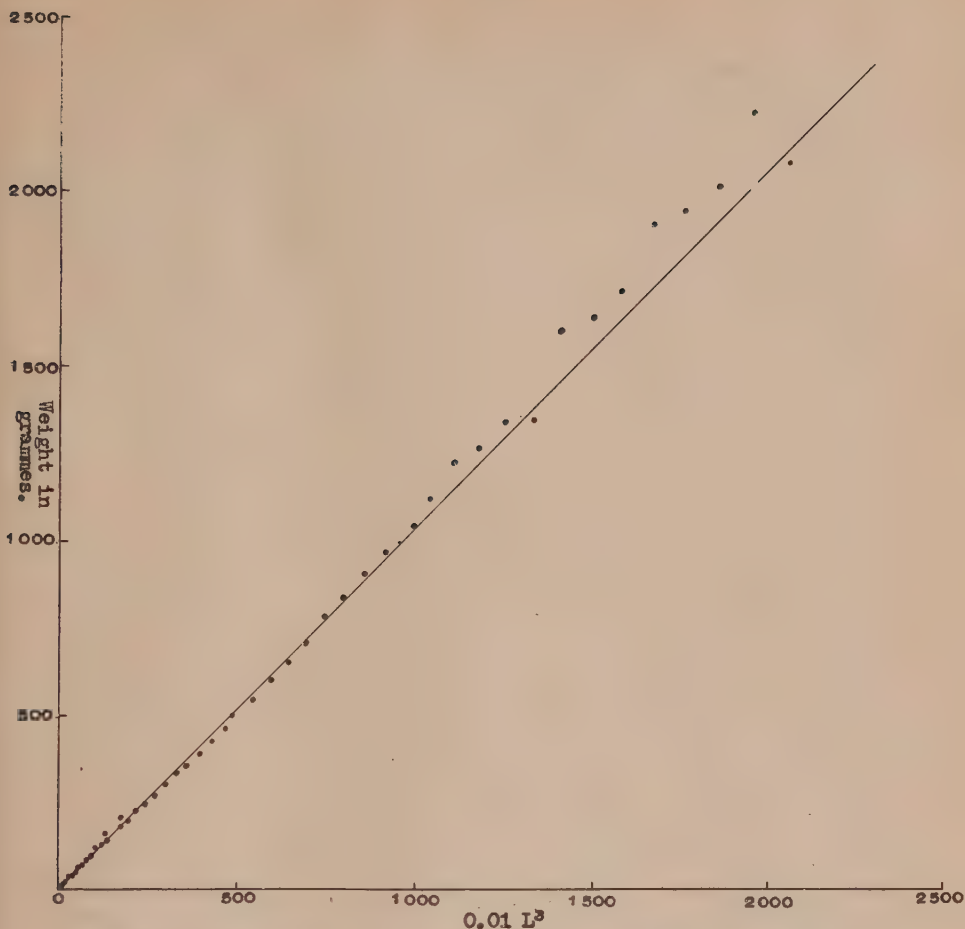


Fig. 5 - The relation between weight (W) in grammes, and volume (V) in cubic centimetres and calculated from $V = 0.1 L$, where L = total length.

Although the detailed measurements required for this table are as yet insufficient to give the consistent progressive increase in weights which is obtainable only from large numbers of measurements (and which has been obtained for whole weights), nevertheless the table shows clearly that the development of gonads is largely at the expense of visceral and somatic tissues. This agrees with a conclusion of Russell (1914) who ascribed a fall in cleaned body weight to "the ripening of the gonad, which implies a transference of substance from the somatic tissue to the gonad".

In the past the weight-length relation has been examined by means of the familiar "condition factor" obtained from the formula, $k = \frac{100W}{L^3}$, which implies that the volume of the fish is a cube of the fish's length (which it is not)* and that the volume is a constant function of the length which, in the case of mullet at least, it is not. If the length term gave a real (or closely approximate) estimate of the volume of the fish then the formula would in effect

* However, the formula above equals $k = \frac{W}{0.01L^3}$ the effect of 100 being as a factor of L^3 and not as Clarke (1938) stated simply to avoid decimals. Actually, also, the formula fits mullet data very well.

be a density one and values of k would be comparable as between fish of different length or of the same length. The experience of workers has been, however, that such values are comparable only within certain limits (vide Clarke 1928; Hickling 1930). Such a difficulty is not unexpected in view of the use of L^3 and a device has been employed by Keys (1928) and Hickling (1930) consisting of fitting a curve with some other power of L than 3; and while this has given a better fit to the data it is still a special formulation of the problem and not general; this particularly applies to the work of Keys by whom relatively small samples were specially chosen, that is, there was no comprehensive series covering the whole range of biological conditions. Keys says that "the form of the fish, therefore, is not constant but changes as it grows"; in so far as this implies allometric (=heterogonic) growth, it does not apply to the major part of the range of size of the mullet (see p. 27); on the other hand changes of form do occur in mullet, chiefly as fluctuations in the length of the abdominal diameters in response to gonad development and spawning. These clearly are not allometric but seasonal, and cannot be accommodated in an allometric formula based upon increments of length; they must be measured and considered as seasonal phenomena. Again mullet do not remain in the same environment but change from brackish and fresh-water habitats to sea-water and it is, therefore, possible that changes occur in density; nor does there seem any reason to accept Keys' conclusion that "there can be little or no change in the specific gravity of the fish as a whole during its growth so long as it remains in the same environment" for that seems counter to accepted conceptions of the purpose of the swim-bladder. In any case the purpose of condition studies is to show such changes. However, the normal condition factor formula has had to cope with both types of change, namely volumetric and densimetric, without, it is felt, showing either; in fact the chief problem has been to decide what was the meaning of fluctuations in condition factor.

The first requirement, therefore, is a precise (or fairly accurate) estimate of the volume of the fish. Mr. D. Rochford of this Laboratory has suggested that the fish be considered as a geometric figure consisting of two cones and a cylinder. This is highly suitable since the fish is divisible into head, trunk and tail sections, which retain constant proportions of the total length of the fish for the greatest part of its life. In addition the co-ordinates of the head and tail figures are fairly constant and, with the length of the trunk section, may be expressed as constant proportions of total length in the appropriate formula. Such a formula is given here:-

$$k = \frac{W}{0.0037 TL^3 + 0.0566 bTL}$$

where, it will be seen, there is a variable (b) consisting of the product of proportions of total length, representing the diameters of the trunk (abdominal) section.* For an account of these sections and the constancy of their proportions see Section 3 (iib). The volume term of this formula may be employed in estimating fluctuations in volume per length month by month. The full formula gives weight per unit volume and as such is a density formula.

* $b = b' TL \times b'' TL$, b' and b'' being proportions of TL representing the diameters of the trunk section.

For mean values of weight and length in mullet the volume term does very closely approximate to $0.01L^3$ as is shown by Table 4A and Fig. 5, the closeness of the fit being dependent upon the adequacy and diversity of the data at each centimetre of length. However, where a fish has weight or volume differing from the normal it is not to be expected that a value of k from a simple formula would be certain to show such difference, or, even if it showed a difference, to indicate its source. A change in weight without change in volume (which is, therefore, a change in density) could not be distinguished from a change in weight accompanied by a change in volume. Values of k have been calculated for mullet and are shown in Table 4B where it will be seen that near-spawning fish have k approximately equal to 1.10 whilst for immature fish k is about 1.000. However, these figures could not yet be used in relation to fecundity or similar studies and work is in train to enable the calculation of volume and weight per centimetre of length and density, at each centimetre of length.

(v) Age Determination and Growth Rate:

Under certain favourable conditions it is possible to procure direct observational evidence of the age of fish and of the rate at which they grow. Such conditions arise in pond culture work. Direct evidence on growth rate is also at times obtainable by means of tagging work. In the absence of evidence of this kind, and for the majority of investigations of marine fish, it is necessary to make the determination of age by indirect methods. Such methods include estimates of the age of groups by examination of the number of separate groups occupying the whole range of size of the species, such groups being assumed to be age groups; this method, which is Peterson's, is valid only under certain conditions discussed below. The other methods involve estimates of the age of individuals by examination of annual records impressed upon such structures as scales, otoliths, and vertebrae. The usual procedure is to exploit the possibilities of the most convenient of the structures for individual age estimates and to use Peterson's method for corroborative evidence.

(a) Evidence from Peterson's Method:

Peterson's method consists of plotting graphically the frequency at each length; by examination the modes of the samples are selected, and these are assumed to represent the modal lengths of successive age groups. By plotting month to month the modes obtained in this way, a progression, which is the growth rate of the fish, can be demonstrated; in addition the distance apart of the different groups also gives an indication of growth rate. This method must be used with care in plotting the frequencies and in selecting modes. It carries the lack of precision which characterises the mode among the other, more accurate, statistical parameters of samples, and at best is only approximate. Also it is of conclusive use only when all age groups are represented or when reasonable evidence is available to indicate the number and the limits of missing groups (vide Colefax, 1931): its use is limited, too, to those species in which the growth rate is fast enough to separate the groups, for where the growth rate is slow (as happens in old groups of most species) the groups intermingle; the method may, therefore, cease to be useful in the senior years.

Again, there is a difficulty that if each year-brood of a stock may consist of a series of distinct sub-broods separated by time or space according to when or where each

sub-brood is spawned, and if such sub-broods remain distinct for one or two years and then gradually mix, becoming finally quite homogeneous, then, under such circumstances, there will be difficulty in reconciling the "pure" modes of the junior groups with the "mixed" modes of the older fish.

Finally, where the "law of the mesh" as enunciated by Buchanan-Wollaston (1927 and 1929) is operative upon any group, it may, as shown by Buchanan-Wollaston in his later paper (1929), cause the appearance of false modes. Unless the law of the mesh for the nets in use is known precisely, the true mode cannot be deduced from the market measurements alone.

There is evidence that all these difficulties have added to the task in the present investigation.

O-Group: (Table 5A). The measurements made by Dannevig in 1903 included some small fish which obviously were O-Group. These were taken in May and June and had modes at 8 cm. and 9.5 cm., and at 8.5 and 11 cm. Other samples have been taken in the course of the present investigation; their modes range from 4.5 cm. to 13 cm., most samples being taken in various months of the year. Owing to the impossibility yet (see Sub-section vii) of determining the time, location, or extent of spawning, no estimate can be given of the age in months of these fish except to assume that spawning took place in about the second quarter of the year; this places broadly an upper limit of eight months and a lower limit of five months on the earliest of these samples. In spite of the incompleteness of the samples there is an indication here of the growth of these fish in their first year.

1+ and 2+ (immature) Groups: (Table 5A). Only a few samples of these groups have been taken. Immature fish of 10 cm. up to about 30 cm. taken between the middle and the end of the year can with certainty be regarded as belonging to these groups; between the beginning and the middle of the year confusion might arise between the larger of the O-group and the smaller of the 1-group; that is, until more precise information is available upon spawning. The samples taken lie well within the scheme of growth rate represented in Figs. 6 and 7.

Older Fish: (Tables 5A - 5F). It will be seen that the bulk of the measurements lie between 25 cm. and 40 cm. except during the months of the travelling season at which time the length increases to beyond 60 cm. In May-June, on Fig. 21(c) there is the one group with modal length about 33 cm., it may be assumed that this is the III group (of 1936); it may be assumed too that its growth as a II+ group is represented in the progression of the mode from March. However, the modes must be handled with circumspection since they may be false to some degree because of the operation of the "law of the mesh", as indicated above. The modes of subsequent groups are not identifiable from these graphs, although they may be inferred from the growth rate of the previous groups and the positions of their modes.

(b) Scale Reading:

Scale reading rests upon the assumption -

- a. that certain marks observable upon the scale are made annually and are therefore a record of the age of the fish, and

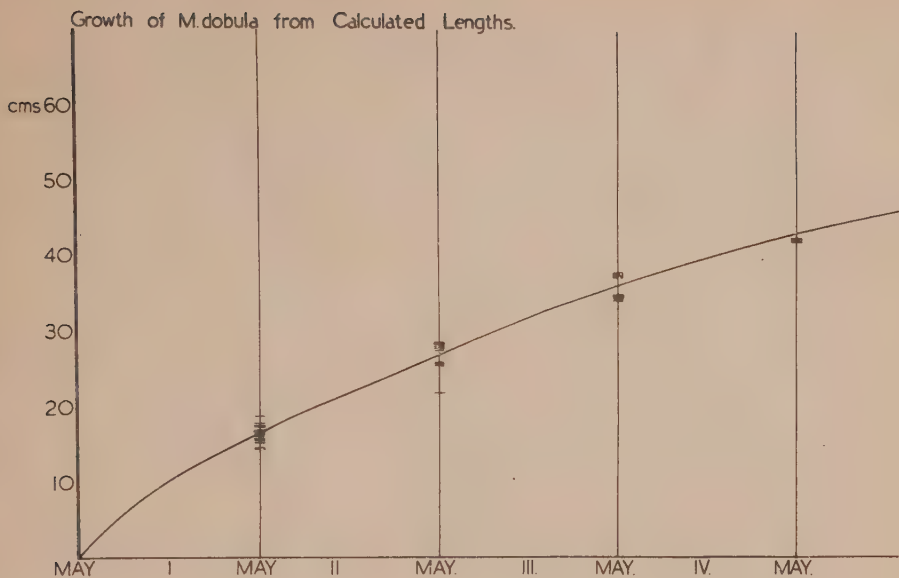
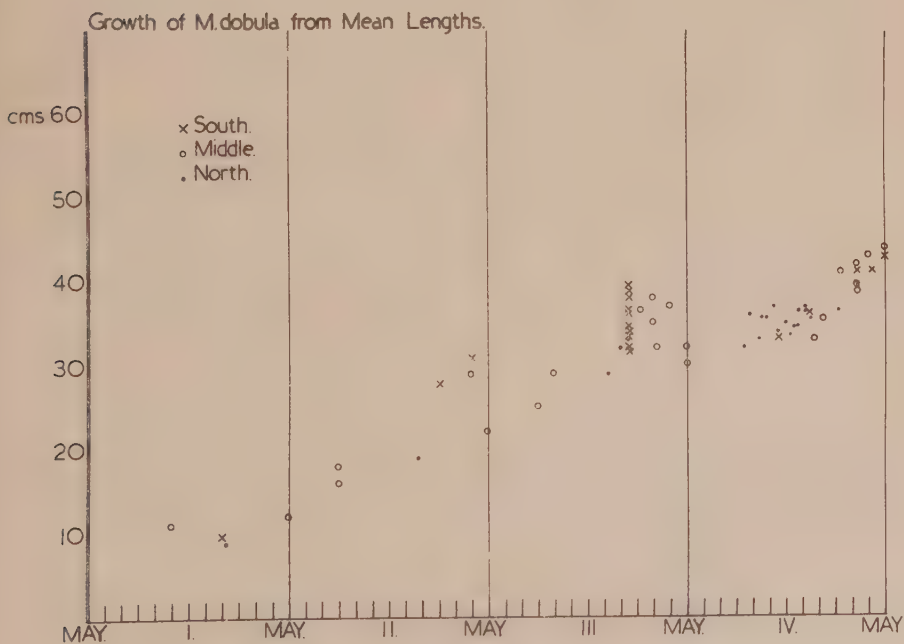


Fig. 6 - Growth rate as shown by calculated lengths at the end of successive years.



- b. that the scale size holds a constant relation to the length of the fish.

Both direct and indirect evidence in support of this assumption is available. On the other hand, the validity of the method can be tested by conformity of its results with other information such as the results of Peterson's method, data on spawning time, and data on the physiology of scale formation and "break" production.

The problem of interpreting scale structure is examined in the section below, while the question of relationship between fish-size and scale-size is examined in the succeeding section.

An account of the apparatus employed in this investigation for the projection of scales has recently been published (Kesteven and Proctor, 1941); since the publication of that paper the optical apparatus has been improved and electric motive power has been provided for moving the screen. The methods are those normally used.

(1) Structure of Mullet Scales, and Interpretation:

An account has been given by Jacot (1920) of the structure of the scale of *M. cephalus* and *M. curema*. *M. dobula* has the same scale structure: it is ctenoid with fairly straight posterior, dorsal, and ventral borders and a rounded anterior border. The rounded border may be ornamented with cteni or may be smooth. Many of the scales from each fish are quite regular, and almost square, but distorted scales also are quite common. The ridged surface of the scale is divided into 4 sectors of 3 kinds; the posterior, anterior, and two lateral sectors. This formation gives, roughly, 4 triangles with apices directed towards the nucleus. These features are shown in Plate 2.

The nucleus consists of two groups of "lines", arced in opposite directions to one another. Each succeeding line, from the blank centre outwards, is symmetrically longer than the one preceding it and the result is two truncated triangles with apices opposed. The centre of the innermost line is taken, arbitrarily, as the datum point for measuring the radius because the distinct lines of the shoulders which separate the sectors, mark, by their convergence, the position of this point (this holds true, even in granulated scales where the nucleus structure - as described here - is obliterated).

Upon completion of the nucleus the lines give place to true circuli which extend across the lateral and posterior sectors. The lines in the posterior sector are roughly double in number the lines of the lateral sectors, and conversely are each only half as wide as those of the lateral sectors. The lines are fairly regularly placed and do not vary greatly in width, that is, in progressing outwards from the nucleus; however, a small number (two or three) of circuli at the inner edge of an annulus are sometimes narrower than the others. In addition to the failure of the extra circuli in the posterior sector to continue on across the lateral sectors there often are a number of incomplete circuli traversing only part of the lateral sector; these commence in the posterior shoulders and are most numerous at the outer edge of annuli.

There is, typically, no differentiation of the scale into "winter" zones of narrow circuli and summer zones of broader ones, but "breaks" occur in the regular disposition

of the circuli and these, by certain structural criteria, can be identified as representing certain events in the life of the fish. Confirmatory evidence to support such identification has been sought, with some measure of success (see below). A "break" is fully represented by:-

- a. The cutting-off of circuli at the outer edge of the annulus and a difference in direction between these circuli and those of the inner edge of the next annulus; this occurs especially at anterior shoulder.
- b. Excessive splitting of the circuli of the lateral sector at the posterior shoulders; this sometimes causes the formation of clear spaces between the ridges or of isolated triangles of ridges.
- c. Formation of a space, wider than usual, between the circuli in the posterior sector; formation of narrow circuli at the inner edge of the annulus (as referred to above) and, sometimes, fragmentation of circuli.
- d. Markings sometimes present in the anterior sector, but this is the least common and least reliable.

It is possible to find a "break" indicated in one sector or shoulder and not in others and to find two or more "breaks" close together. The decision upon these relates to a matter of interpretation of scale phenomena. The appearance of the complete "break" (that is, of one exhibiting all or most of the above structural criteria) suggests, quite convincingly, that feeding had ceased for a period during which resorption may have occurred; at any rate at this time the circuli were differentially shortened; at the end of the period, with the resumption of feeding, scale accretion was resumed, but in such a manner as to produce complete circuli lying at a different angle to those of the previous annulus. This assumes no more than is normally assumed in interpreting scales, and is sufficient explanation of the origin of all "breaks". The next problem then is to indicate the possible causes and frequency of such cessations of feeding. In the section below on feeding it is stated that mullet derive food from the mud and sand which they suck in from estuarine and lake bottoms; this is supported by every writer upon mullet; there is evidence that this is the only food and that, therefore, when the fish go to sea, their feeding ceases. The sea-migrations are therefore assumed to be the main cause of cessation of feeding, but evidence is yet insufficiently complete to say whether cessation of feeding at sea alone can cause "break"-formation: the possibility exists that feeding could be stopped, by internal rhythm (see Dakin, 1939) among fish unable to go to sea (such as those land-locked by a closed lake), and that a "break" could then be formed. However, a fish which was tagged in Lake Illawarra in January and which was recaptured in June in the same lake, grew approximately 3 cm. and whilst this growth is shown on the scales at recapture, as compared with the scales at the time of release, there is no sign of a "break" although the fish was free for the five months in which migrations are made and in which, apparently, "breaks" normally are made. This piece of evidence indicates at least that a fish may fail to record a "break", and it lends support to the practice of assuming such omissions to have occurred on scales whose apparent

age is less than that which might have been expected from the size of the fish. Again, extreme cold weather could depress metabolism and rate of feeding, to the same effect: but such extremes are neither great nor continuous in these coastal waters. Among these possibilities the migrations in autumn, which are at or near the anniversary of spawning, are the most consistent and of apparently greatest duration, and it is assumed that this is the annual event recorded on the scale. A "break" made by this has, because of the greater duration of the event, greatest chance of being complete and, therefore, in reading, the succession of complete "breaks" is looked for. In the section on migrations evidence is presented that other migrations occur besides the autumn one, and if a "break" were formed at each then two or more "breaks" could be recorded for one year. That this is so is indicated by the frequent presence of more "breaks" than seems admissible for the length of the fish. In cases such as these, a choice is made between the "breaks" upon the basis of the criteria; also the intermediate length to each "break" is calculated and those lengths rejected which are not in conformity with the remainder of the sample and with the general indications of the Peterson method.* At first sight it would seem that an arbitrary procedure such as this would set up considerable difficulties, but in practice it is better than it would seem and there does not appear to be any alternative in the problem. This is in effect the same conclusion as in Thompson (1923) - "If a scale places a Haddock outside its age group in point of size, aid may be sought by counting the sclerites, and comparing the intermediate measurements of the scale with other fish with the same size of scale; if these means and a thorough examination of other scales from the same fish fail to reveal a discrepancy, the fish must be credited with the observed age." A system such as this can include the bulk of scales encountered.

The opposite condition to that indicated above, namely the possession, apparently, of too few "breaks" may occur but may be dealt with according to the same system; that is, the reading of a scale which seems to indicate that the fish lies in another age group to the one in which its size would suggest that it lay, is to be tested by comparison with other fish of the same sample and with the results of Peterson's method.

The position taken here may be summarised: It is assumed that during each year a "break" is recorded on the scales of the majority of mullet as a physiological consequence of such events as the migration to sea (to spawn or to avoid flood-waters), during which feeding must cease; it is accepted that these events need not be precisely at the anniversary of the birth of the fish; it is assumed further that two events, similar or dissimilar, happening in one year, could cause the appearance of two "breaks" and conversely a "break" could be omitted. In spite of the apparently sweeping nature of these assumptions, there is a reasonable amount of supporting evidence, and the results of direct age-reading and of calculations of intermediate lengths show quite good consistency with other data.

(2) Scales from Individual Fish: The examination of scales from individual fish has been made to determine what scales should be taken from each fish, and also to test the validity of the assumption (fundamental to the theory) that a constant relation exists between the length of a scale and the length of the fish.

* Vide Jacot (1920) with whom this in part agrees, and Hubbs (1921) with whom it disagrees.

Rejected scales: the lengths l_1 and l_2 were sometimes unreadable because of nuclear granulation, and these scales were not used at all although the later l_3 and l_4 lengths were apparently quite acceptable. The distribution of granular scales upon the side of the fish examined was quite irregular, but a lower percentage was found in the central flank region. It seems that the percentage of such scales increases with age, but whether there is any significant correlation is not yet determined. The cause of these scales is not known.

In addition to rejections because of granulated nucleus, other scales are rejected because of excessive distortion; the scales lying outside the linear series of the flank (as described on p.26) are generally of this type, and so are some of the marginal scales within the series. The smallest percentage of rejected scales is found in the area in the neighbourhood of the tip of the pectoral fin.

Scale size: In addition to having a high percentage of rejected scales, the areas outside the linear series of the flank have considerable variation in scale size and, therefore, the scales in these areas were not taken. On the other hand, although the scales of the flank show little variation in size, as is shown in Table 6, the scales of the area near the tip of the pectoral fin show least variation and are, therefore, preferable; however, the variation is so small, and, as shown below, is of so little consequence that where these scales were unobtainable, others were taken in their stead, and used with confidence.

Calculated intermediate lengths: Table 6 shows the calculated intermediate lengths, and the increments which these represent, for many scales taken from each of a number of fish. It will be seen from this table that the results are very uniform for each fish although there is variation in the size of the scales. The uniformity of results in spite of variation in scale size means that there are different coefficients of regression of scale size on fish-size, and that these different coefficients are real and operative over the whole life of the fish for each scale. In other words, each scale holds its own constant relation to the length of the fish, and proportions of scale-size have direct relation to proportions of fish-size. Such a condition would be acceptable to the system established by Buchanan-Wollaston (1934), by whom the continuity of regression was tested as a mean line among an unbroken series of variations, normally distributed. It is contrary to the finding by Thompson (1923) for Haddock where -

- a. care must be taken to select large scales because the small ones gave low calculated lengths, and
- b. the scales of the pectoral region grew slowly at first (for about three years) and then faster so that compensation was effected.

In the present work there is no sign of such changing growth rates among the scales, and in view of evidence elsewhere of the isometric growth of mullet this is not surprising.

In the absence of any sign of changing growth rate among scales it is assumed that the mean calculated lengths, of all such lengths calculated for each fish, are the true

intermediate lengths for each fish, and that those scales which as a group lie closest to these means are to be considered preferable. On this score the flank scales selected before are again the best.

(3) Excessive (False) and Omitted Annuli: In the section above on the interpretation of scales, it was stated that the production of false rings, additional to true (anniversary) rings, and alternatively the omission of rings had been indicated by the biology of the fish and in the preliminary examination of scales. There was also some direct evidence from one tagged fish. The consequence of this to age-determination studies might have been considerable, but at present it is felt that the major consequence is to cause the rejection of the intermediate length and increment data from some fish with scales of this kind. Nevertheless it can still allow the use of the scales for simple age-determination provided the samples are of sufficient size.

The results of reading a sample of scales from fish caught in Port Hacking, are shown in the table below:

	$\bar{x}$	Mean T.L. cm.	Mean l_1 cm.	Mean l_2 cm.
I+	28	17.09	9.82	
II+ {	I+?	3	26.37	-
	I+?	23	27.24	-
		5	29.62	19.90
All II+	31	27.54	12.35	20.41

Port Hacking 2nd August, 1939.

These scales at first sight fell into two groups, I+ and II+ of which there were 54 of the former and 5 of the latter; of the 54 I+ scales, however, only 28 are held to be genuine I+, the others are probably II+. The 26 apparent I+ scales cannot be I+ with the true I+ taken in the same sample because the difference between the mean total lengths of the two groups is too great - it is such as can be expected for the growth during the second year; moreover the mean length (27.41 cm.) of the apparent I+ fish falls close to the mean length of true II+ fish in the same sample. It is thought that these apparent I+ fish have omitted one ring which was, in some cases, the second and in others the first. The closeness of l_1 and l_2 of the apparent I+ fish to those lengths in the 5 II+ fish is reasonably good, and if all the measurements for these fish are added together and new means taken there is an even closer approximation.

A further example, showing an l_2 probably omitted, is given in the next table:

	$\bar{f}$	Mean T.L. cm.	Mean l_1 cm.	Mean l_2 cm.
I+?	17	30.14	16.45	-
II+	30	30.75	15.55	23.68
All	47	30.53	15.86	-

Tuggerah Lakes, 4th June, 1940.

It could not be accepted that these two groups could be separated by one year in age, especially since they apparently exhibited the same growth rate during the first year.

The omission of the second ring and the production of an extra (false) third is indicated in these scales:

	$\bar{f}$	Mean T.L. cm.	Mean l_1 cm.	Mean l_2 cm.	Mean l_3 cm.
I+?	8	33.9	15.4	-	-
II+	28	31.8	14.4	24.0	-
III+?	12	33.8	15.5	23.0	29.8
All	48	32.7	14.5	23.7	

Clarence River (Grafton), 19th August, 1941

Finally, the fish of the sample below are in two groups apparently having a difference of one year in age, the small difference of total length makes it difficult to accept the age diagnosis as it stands.

	$\bar{f}$	Mean T.L. cm.	Mean l_1 cm.	Mean l_2 cm.	Mean l_3 cm.	Mean l_4 cm.	Mean l_5 cm.
IV+	11	41.0	14.2	24.5	32.4	33.2	-
V+?	29	40.7	12.2	20.9 24.6	26.2	31.1	36.8

Clyde River, 24th August, 1939

In this case the agreement between l_3 and l_4 of the IV+ groups and l_4 and l_5 of the V+? groups suggests that the reading is in error in respect of l_2 and l_3 in the V+? group. On second inspection of the V+? group, a choice was made between l_2 and l_3 of each fish, one length being retained and considered as l_2 from which a new mean, 24.6, was obtained; the lengths l_4 and l_5 then become l_3 and l_4 and fit very closely with those lengths in the true IV+ group.

From evidence of this type it is concluded that valid results, at least in respect of age-determination and often in respect of intermediate lengths and increments, can be obtained from scales in samples of sufficient bulk, provided care is exercised.

(c) Growth Rate:

Table 7 sets out the number of mullet of each age group at each centimetre of total length. Each age group occupies a considerable length range and the ranges of the groups overlap greatly. The width of each range is due to the fact that it extends from the meagre measurements of dwarf fish taken at the beginning of the biological year to the great measurements of giant fish measured at the end of the year. Over such a wide range, with the small amount of data yet available, the effect of special sampling is revealed in the multimodality of the distributions. If the samples were drawn at random in respect of the factors with which length is correlated, and of those by which it is determined, then the distribution would probably be normal; however, the heavy sampling at some times, especially during autumn, destroys the randomness. The factors responsible for variance in the distributions are (1) time of measuring (in the biological year), (2) sex, (3) individual genetic effects, (4) geographic effects, and (5) an assemblage of factors collected under the term "brood", referring to success of hatching and subsequent growth rate of each year's spawning. The effect of time of measuring can be eliminated by considering calculated intermediate lengths which are the lengths achieved by the fish at the end of successive years; these lengths retain the variance due to the factors (2) and (5) above, and there is error due to the technique of scale reading. An examination is made below of these measurements. The effect of time of measuring, which is in fact the question of period and rate of growth within each year, can be examined by a consideration of marginal increments; this has been done in the second section below.

(1) Intermediate Lengths and Increments, Calculated from Scale Measurements: Table 8 gives the mean values for calculated intermediate lengths and for increments, of fish of various ages. These may be accepted as approximate estimates of normal values of the lengths achieved by *M. dobula* at the end of each year. Whilst the mean values given show variation, they do not indicate the full range of the variation among individual observations. This variation is in fact considerable; *a priori* it may be assumed to be due to any or all of the factors listed (2) to (5) above, plus certain possible factors in the technique of sampling, measuring, and age-reading. These additional factors are known as Lee's Phenomenon, the Law of Growth Compensation, and Experimental Error. Buchanan-Wollaston (1931), in considering the factors affecting growth of fish, speaks of divergent, parallel, and convergent growth; to the term "divergent" belongs growth determined by all the factors above except the Law of Growth Compensation which would be responsible for convergent growth. It is proposed here to use the terms dispersive and adducent factors for approximately the same meanings as divergent and convergent, since it is felt that these terms are more appropriate to the actual conditions of scattering values arising from diverse points on the time axis. It should be noted that in some cases dispersive factors could cancel out and produce, by opposing operations, an adducent effect: thus, the migration of a fast-growing group into an area of

poor sustenance and conversely of a slow-growing group into an area of good sustenance could lead to both groups attaining similar values.

In order to assess the importance of the dispersive factors, various statistical methods have been applied to groups of data. Although the methods and results of this work are reported here, it should be pointed out that this work is regarded as being of no more than preliminary nature, leading to later work with more rigorous methods. The present results are somewhat inconclusive but serve chiefly to indicate lines of further investigation.

Dispersive Factors:

Sex: In Table 8C is given a summary of the age-reading of fish of which records of sex had been taken. It will be seen that in general the differences between the sexes are small and occur without any definite system: in any age-group the ascendancy of one sex over the other in one year is often reversed in the next year. The possibility exists that these results are in part due to the effects of sampling in locality or year, and this is confirmed by reference to the data of particular samples, some of which are given below, where differences are considerably reduced.

<u>Age</u>	<u>Sex</u>	<u>$\bar{f}$</u>	<u>TL</u>	<u>l_1</u>	<u>l_2</u>	<u>l_3</u>
<u>Sample PH23, Port Hacking, 22/10/41.</u>						
II+	M	42	31.0	15.6	23.6	
	F	15	31.2	15.0	22.2	
III+	M	45	35.5	13.2	23.8	30.1
	F	7	35.1	13.5	23.1	29.8
<u>Sample 39/44, Maclean, 6/6/39.</u>						
II+	M	23	34.2	12.7	26.0	
	F	14	36.0	14.6	24.3	
<u>Sample 39/1, Grafton, 26/1/39.</u>						
III+	M	33	35.2	14.4	21.6	30.0
	F	6	37.4	14.3	20.2	31.3
<u>Sample. Maclean, 26/6/41.</u>						
II+	M	10	32.6	12.0	24.1	
	F	25	32.7	12.3	23.9	
<u>Sample. Tuggerah Lakes, 17/7/41.</u>						
III+	M	7	36.0	11.7	22.3	29.5
	F	11	35.6	12.7	22.4	29.1

These samples have been chosen as showing the closeness of the agreement between the lengths of the two sexes in the one sample; although there are samples which do not show such close agreement as these, in general the agreement is of this kind and leads to the conclusion that the growth rate is much the same in both the sexes, at least that, at the present stage of the work, no distinction can be made between them. Finally, there is a suggestion in Table 8C that the females take a lead in growth rate during the fourth year; however, this requires more evidence.

Lee's Phenomenon of apparent change in growth-rate: In many species of fish (notably in the herring where the observation was first made) workers have found that the value determined for l_1 , and for subsequent intermediate lengths, varies inversely with the age of the fish for which the determination is made. This phenomenon, of which no fully satisfactory explanation has yet been offered, can be considered as possibly falling within any one of the following groups of effects:

- (a) statistical, being a confusion of locality and other effects;
- (b) technique, as a consequence chiefly of special sampling, by nets;
- (c) population change, due to selective mortality caused by fishing or by some natural selective factor;
- (d) physiological, as a result of which progressive changes in scales produce corresponding discrepancies in the calculations of intermediate lengths.

In view of these possibilities it is clearly insufficient to draw conclusions from figures such as those presented in Table 8. In those tables it will be seen that parts A and B show no sign of progressive decrease of intermediate lengths but instead, in Part A, a progressive increase (with exceptions) in lengths l_2 to l_5 ; in Part C there is a rough progressive decrease of l_1 . The presence of Lee's phenomenon in the one place, and its absence in the other together with an alternative reverse phenomenon cannot be interpreted, or even accepted; there might be extensive confusion effects either producing or concealing phenomena.

On the other hand, the comparison of calculated intermediate lengths with observed lengths is considered invalid, since calculated lengths are lengths achieved at the end of the growing-year and observed lengths are comparable, therefore, only when the year's growth is completed; since this can be confirmed in many cases only by scale reading, the two values are then insufficiently independent. No attempt at adjustment of during-the-year observed lengths, is justified.

In order to make a comparison among intermediate lengths freed of possible locality effects, data were taken consisting of lengths calculated from scales from fish caught in Port Hacking within a short interval of time. These lengths were arranged in groups according to the age of the fish from which each was taken. Examination of the mean values showed definite differences but no apparent order in the differences. Two statistical tests were made of the data. The first, devised by Bartlett (1937) and described by Snedecor (1940) consists of a corrected χ^2 test of the homogeneity. The analysis of the variance of the means showed that for most lengths there were significant differences among the means. This result, whilst leaving the problem of Lee's phenomenon unsolved, suggests a final line of approach. The undoubted differences between the means, since they occur in no order such as would be expected if Lee's phenomenon existed among these fish, may be accepted, temporarily, as an indication of differences among year-broods, and this means that the intermediate lengths of separate year-broods must not be compared but that the comparison must be made between separate age-groups

of the one year brood. Unfortunately the data available allow comparisons between only two or three age-groups of any one year brood; and whilst such minor comparisons show both presence and absence of the phenomenon, the result is inconclusive.

Other dispersive factors (season, locality, and heredity): In conformance with the finding of workers on other species of fish, it is natural to nominate season and locality as factors responsible for differences among groups of fish and to expect heredity to account for some residual variation. The likelihood of this was indicated in a previous section, but the analysis of the factors rather defies the quantity and quality of the data available. Tables 8E and 8F set out the first approach to this problem. From the first part of each table can be read the values of l_1 , l_2 , etc. for various year-broods at different ages as determined by the year of capture. These are summarised into the second part of the table where the mean value for each year's growth has been taken regardless of the age of the fish from which it was read. From this table the history of each year-brood can be followed; thus the growth by the 1931 year-brood in 1931, 1932 and so on is shown in Table 8E. Now presumably the relatively great growth of the 1931 year-brood could be due to (a) its being genetically a fast growing brood, (b) the locality in which it spent 1931 being especially favourable, or (c) the year 1931 being an especially favourable year; equally these factors could all combine for or against a brood. Growth of this brood in succeeding years would be subject to these factors. It is a remarkable fact that mean values for each of these lengths for the two representative localities chosen, show extraordinary similarity; if it were not for an ineradicable suspicion that these similarities could be due to confounding of major effects, this result might be taken to indicate that locality had little effect on the mean growth rate of the fish. On the other hand such a conclusion is supported by the general features of the biology of this fish, in respect of its migrations; that is, although the fish included in Table 8F were all captured in Port Hacking, it is extremely probable that many of them spent most of their life in localities further south; thus, the V+ fish of 1934 brood captured in 1939 could have come from a great deal further south than the III+ fish of the same brood captured in 1937. It is probable, therefore, that, until tagging reveals further information, it will not be possible to assign any quantitative role to locality as a factor determining growth. Equally truly, whilst the possibility of locality effects exists, an assessment of the value of any particular year for growing cannot be made with any confidence.

Growth Compensation:* It has been shown in some species of fish that a sub-normal growth in one year is compensated by extra growth in the following year, and vice versa. In some species this "compensation" has been noted in year broods; in others it has been noted in individual fish. This effect, which is known as a compensation phenomenon, was discussed by Hodgson (1929) who suggested that it was more apparent than real; he suggested that the effect was produced principally by differences in time of spawning as a result of which a late-spawned fish, being younger at the end of the biological year than an early-spawned fish, will at that time be shorter (by virtue simply of having had a shorter period of growth)

* This question is being considered more fully in a paper now in preparation.

and will be capable of a greater increment in the next year, although not necessarily reaching the length achieved by its elder brother. As a result, any apparent increase in growth rate during the second year will in effect be only a continuance of the normal growth rate. Ford (1933) replied to these suggestions saying that fish could be spawned at the same time but have different growth rates, and as a result achieve different lengths by the end of the biological year; Ford argued that this might dispose of Hodgson's effect and he left the inference that the compensation phenomenon could be superimposed upon these genetic differences. Other workers (e.g. Hile 1936) have considered that their material showed compensation phenomenon, and have spoken of a law of growth compensation. Variations in the growth rate of individual fish have been shown, but that size achieved at any point should have a directive inverse influence on growth subsequent to that point is, while contrary to normal concepts of growth functions, as yet not shown. Without deciding upon the possible cause of the effect, an examination may be made of the relationship between the various calculated intermediate lengths.

It can be shown that if a set of pairs of values for l_1 and i_1 be obtained from two independent sets of values of limited range by random methods (say by dealing cards), and if a third set (representing l_2) be obtained from the first two sets by adding together the values of each pair, then, while the correlation between l_1 and i_1 will be of no significance, the correlation between l_1 and l_2 will be fair, that between i_1 and l_2 will be good, and the multiple correlation coefficient will have high significance. Moreover, both coefficients of the multiple regression will be significant, and the multiple regression equation itself will be significant. If, instead of obtaining both sets of values (l_1 and i_1) by random methods, the values for l_1 are obtained by random methods but the possible values for i_1 are paired with the values of l_1 so that there is a constant association of the lowest value of the one with the lowest value of the other, the next lowest of the one with the next lowest of the other, and so on, then the coefficients of correlation are increased, and that between l_1 and i_1 becomes significant. Alternatively, if, in arranging the values for i_1 , the lowest possible value for l_1 is paired with the highest value for i_1 , the next lowest of l_1 with the next highest of i_1 , then in this case, the correlation of l_1 with i_1 remains significant but becomes negative, and all other correlations disappear; moreover, all values of l_2 become equal. This last case represents an extreme form of compensation. These results can be compared with real data obtained in the course of scale reading.

For this purpose groups of data taken in Port Hacking in the one year (1939) were used. In the first case II+ fish gave the following information:

	l_1	i_1	l_2
Mean	14.3± 2.92	11.2± 2.60	25.5± 3.61
l_1 Regression*		-0.105	0.915
Correlation		-0.09	0.75
i_1 Regression			
Correlation			0.44

$$l_2 = 1.0073 l_1 + 0.5256 i_1 + 5.21$$

both coefficients for this equation, and the equation itself, are significant.

* The coefficients in the table are total coefficients.

Of the correlation coefficients, l_1 with i_1 is not significant, but l_1 with l_2 , and i_1 with l_2 are. With the significance of the multiple regression equation, this is the same result as for the first case above and suggests that the growth in the second year is somewhat independent of the growth achieved in the first year. But, in spite of the slight negative regression of i_1 and l_1 (which is, moreover, statistically insignificant), the effect of the multiple regression is positive so that a fish which is large to begin with will continue to be large, and, in effect, while environmental factors exercise influence on the growth within the year (as shown by the independence of l_1 and i_1), the genetic factors exercise an over-ruling effect.

In the second case III+ fish gave the following results:

	l_1	l_2	l_3
Mean	13.4± 2.54	23.5± 2.79	32.0± 3.18
l_1 Regression		0.612	0.414
Correlation		0.56	0.33
l_2 Regression			0.64
Correlation			0.56
$l_3 = 0.3005 l_1 + 0.625 l_2 + 13.286$			

Although neither of the coefficients is significant the equation as a whole is highly significant. Of the total correlation coefficients, l_1 with l_2 and l_2 with l_3 are significant, but l_1 with l_3 is not.

Finally, IV+ fish gave these results:

	l_1	l_2	l_3	l_4
	14.5± 2.85	25.3± 3.21	33.3± 3.62	38.8± 3.80
l_1 Regression		0.726	0.498	0.182
Correlation		0.65	0.39	0.14
l_2 Regression			0.805	0.547
Correlation			0.72	0.46
l_3 Regression				0.870
Correlation				0.82
$l_4 = -0.212 l_1 - 0.188 l_2 + 1.059 l_3 + 11.4086$				

Of these total correlation coefficients l_1 with l_4 is without significance, l_1 with l_3 and l_2 with l_4 are between the 5 per cent. and 1 per cent. levels; the remainder are significant. While the multiple regression is significant, only the third coefficient (of l_2 with l_3 holding l_2 and l_1 constant) is significant. These two examples confirm the deductions from the earlier one, namely that the growth in successive years tends to be independent and that much of the correlation between lengths at the end of successive years is due to common elements. On the other hand, the positive character of the regressions leads to the conclusion that there is no compensation phenomenon in the samples handled. This absence of the compensation phenomenon has not been proven for all localities, but the similarity of other data with the above suggests that the present conclusions are true also for elsewhere.

(2) Observed Lengths and Marginal Increments, as Indicators of Period Growth (within the year): The mean values of observed lengths and marginal increments of age groups 0 to VI+, during the months of the year, are given in Table 9. The meagreness of the data is revealed in this table, which shows no especial growth period. There is some indication that each age group tends to achieve its maximum

towards the middle of the year and that new growth commences about June-July.

(vi) Gonad Maturation, etc.:

(a) Stages of Gonad Development:

When this work was commenced a tentative table of stages of gonad development was prepared. However, at that time (October, 1937) the fish were generally in immature stages, I and II of the table now in use, and because of inexperience unsatisfactory identifications were made. These data have, therefore, been rejected. The scheme now in use is given in Table 10; this is held to be liable to modification when further work, chiefly histological studies, has been done. The following comments may be made upon the table.

(1) Female fish:

Stage I is essentially virgin. Many of the winter and spring fish (at the markets) are in this condition.

Stage II is assumed to include recovering as well as virgin fish. It is fairly easy to distinguish this stage from I and III when one is familiar with the fish and when these stages are available for comparison, although it does in fact grade out of and into those neighbouring stages. It is retained chiefly for the use which may be made of it in placing the recovering fish in a system.

Stage III is the first appearance of pigmentation in the small gonads.

Stage IV is the first stage of discrete eggs. The gonad is, compared with the preceding stages, quite large, and probably the first sign recognised by fishermen as "making roe".

Stage V immediately precedes spawning; no female fish riper than this has yet been secured. The ovaries in this stage are relatively immense, up to 20 per cent. total body weight; pigmentation is heavy, ova are discrete, very nearly free enough to run easily and may approach closely to clearing in sea water. With heavy pressure eggs can be forced from a fish in later Stage V, but experimentally such eggs have never cleared properly or become fertilised by artificial methods used.

Stage VI has not been seen, it is defined here on customary criteria.

Stage VII is of doubtful existence and value for female fish, but was included against the possibility that spawning might be intermittent and occur; however, evidence is given below (p. 52) that this is probably not true.

Stage VIII has been observed in only few fish.

(2) Male fish:

The stages are not so clearly differentiated in the male as they are in the female, since the differences are in degrees of length, width, and fatness which imperceptibly intergrade; except for I and VIII there are no 'discrete'

differences. In the early stages the testis is identified by its sharp outer edge.

Stage I is fairly easily distinguishable as a definite thin strap with sharp outer edges.

Stages II, III, and IV are comparative.

Stage V. It is assumed that some of the fish with large testes, from which milt can be secured by hard pressure, and which accompany the schools of Stage V females, also are in Stage V.

Stage VI is easily secured, in the spawning season.

Stage VII is quite definite in males with characteristics as described in the table.

(b) Seasonal and Geographical distribution of Gonad Stages:

Table 11 summarises the observations upon distribution of gonad condition. It will be seen that the more mature stages are restricted to the autumn and early winter months, extending over-all from March to July. In the south the season begins in March (or possibly earlier, in February) and continues until May; in the north the season commences in March and lasts until June: finally, in southern Queensland the season extends until July. The regions chosen into which to assign the data in this section, are purely arbitrary at present; the first is from Eden to Port Hacking inclusive, the northern from Port Hacking to Tweed River, and the Queensland region simply includes the samples taken in Queensland. The arbitrariness of the delimitation of regions, however, does not lead to any error, for the sampling has been fairly comprehensive and any type of subdivision would reveal the same condition, namely, a continuous shift of the centre of concentration of near-spawning and spawning stages. It seems very likely that this progressive ripening of the fish northwards coincides with, if not being an actual response to, the decline of temperature in these onshore waters with the northwards march of winter. The gradual decline in temperature in the summer-autumn period could initiate the gonad development, and the change occurring with the onset of westerly winds could provide critical temperatures initiating the migration. However, this is purely conjectural and this relationship requires further examination.

(c) Length and Gonad Stages:

In the observations made the small fish are characterised by small glassy gonads, grey or bloodshot, and it is only in the bigger fish of the samples that pigmented ova are seen. The presence of pigmented ova is taken as a sign of the onset of maturity, and, with a few exceptions, the females with such ova and the males with corresponding testes are all larger than 31 cm. Table 12 sets out the correlation of length and gonad stages; certain aspects of this table call for comment. In the first place it would be possible by measuring at appropriate times, as Table 11 shows, to have nothing but ripe fish in this table; but, as examination of the sample lists will show, there has been no such selection, and the figures given may be accepted as random and fairly representative. It might be thought that the methods of sampling (which took place in the markets) would exclude the smaller fish from examination, but the tables show that this is not so, although the tables do

show that the numbers examined are yet too small to be free of the influence of special samples, that is, the totals are quite irregular. The small numbers in Stages III and IV of the males and IV of the females may be due to chances of sampling, or to the difficulty in identifying these states. The indications from this table are that the general run of fish mature first when about 30-34 cm. in length, that is, at the end of their third year.* It is impossible yet to say whether all fish mature at this time or whether any proportion of them delays first maturity until the following year; this is chiefly because of the inability to distinguish satisfactorily between virgin and recovering fish.

(d) Sex Ratio:

In Table 13 the number of each sex in each sample is recorded with the percentage that those numbers are of the sample totals. Although the grand total number is not great (and, for that, the proportions are 36.2 per cent. females to 63.4 per cent. males) there are enough samples to indicate that general ratio in the catches; the mean proportions are 34.4 per cent. females and 65.5 per cent. males, roughly there are two males to each female. This may, however, be due to differential fishing, but it is established, for Queensland at least, that males are often rejected at the net and only females taken to market; if this means anything to the above figures it is that the true ratio in the population could be even wider still. If the above ratio were true for the population, then caution would be needed to ensure that fishing remained proportional.

(e) Fecundity:

Tosh (1903) made an estimate of the number of eggs in the ovary of a mullet and found two million and two and a half million in two fish examined. In the present investigation a series of 29 gonads was examined by first weighing the gonads then weighing small portions and counting the eggs contained. Three portions were taken from each ovary: anterior, middle, and posterior; from these six samples an estimate was made of mean ova weight from each ovary. An examination by measurements with an ocular micrometer under a microscope revealed that there was one size group of ova in each ovary, differences among the ova of each ovary arose from distortion due to compression within the ovary. This general homogeneity was revealed also by the estimates of ova weight. Although these weights showed an apparent slight gradient of weight from the anterior to the posterior end of the ovary, an analysis of the variance among the 166 mean ova weights showed no significant difference in weight between ova of right and left ovary or between ova taken from anterior, median, or posterior positions in the ovary; by far the greatest part of the variance arose from the differences in stage of development. The mean weight of approximately mature ova was 1.7 milligrammes, but since this work was on formalin preserved material the real (live) weight might be slightly different from this. Direct computations of ova number from the gonad weights and the mean ova weight gave values ranging from 1,275,000 to 2,781,000.† There was positive increase in ova number with increase in total length of the fish; this was expected, since the size of

* Faouzi (1937): "as for *M. cephalus*, sexually ripe females were at least 33 cm., males 31 cm., long."

† These estimates are in error to the extent of the proportion of the gonad weight which consists of supporting tissues within the ovaries. This proportion, however, was shown to be insufficiently great to invalidate the work at this stage.

ripe eggs has been shown constant for each species, and many workers have shown that the gonads have some exponential relation with length (Wynne-Edwards, 1929). Fig. 8 shows the approximation of growth in body weight to growth in gonad weight. The weight of the mature gonad as a proportion of total weight increases slightly with length, the equation being $y=6.6+0.09x$ for females and $y=4.48+0.027x$ for males over a range from 35 to 59 cm., (y equals 100 gonad weight, x equals total length in centimetres).^{*} However, it is difficult to see how such a small rate of increase of proportion as this could become lethal as suggested by Bidder (1925) and Orton (1929).

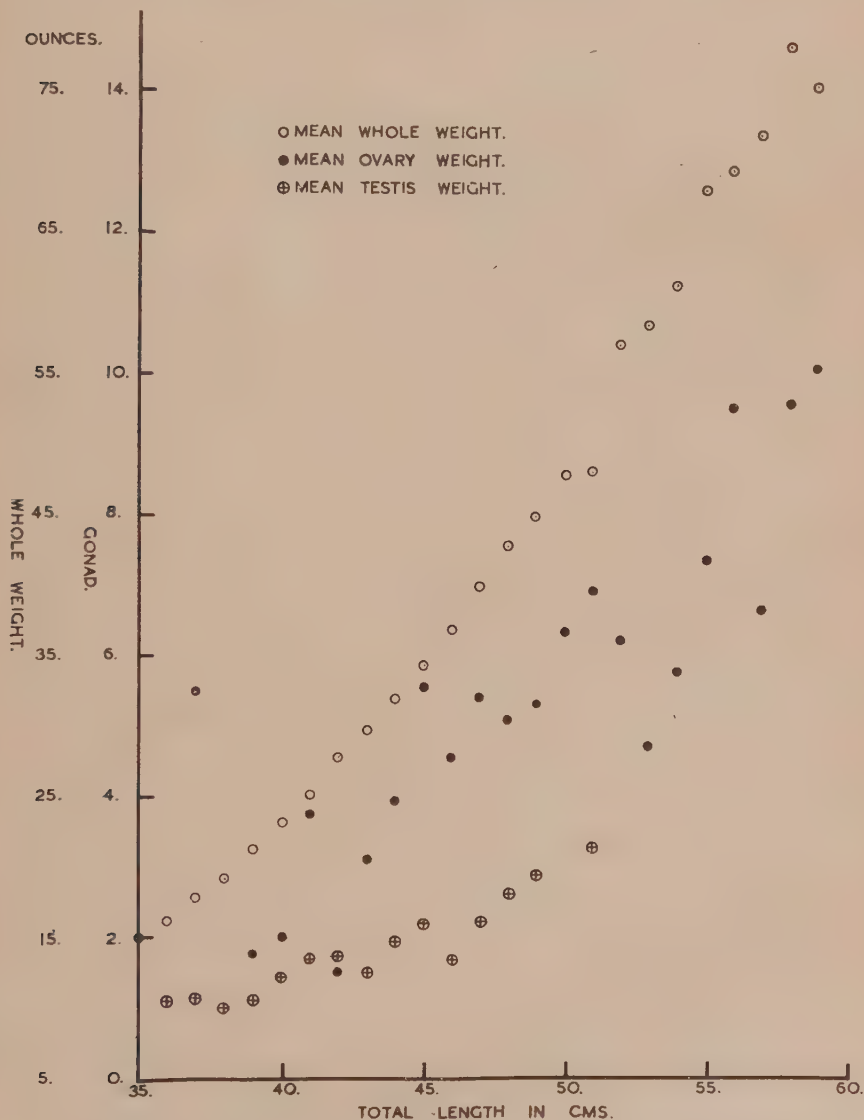


Fig. 8 - Relation between whole weight and gonad weights.

^{*} See Table 14. A certain proportion of the irregularity of this table must be ascribable to false identification of maturity stages.

Stage of Development	Mean Ova Weight - in milligrammes						Mean	Number of Gonads
	Left Gonad:			Right Gonad:				
	A	M	P	A	M	P		
IV	.40	.43	.44	.43	.42	.46	.43	14
IV+	.95	.89	.98	.98	.78	1.08	.93	4
V	1.37	1.40	1.59	1.30	1.39	1.54	1.41	11

(vii) Spawning, Embryonic and Larval Life:

Unfortunately spawning has not yet been observed and the eggs and larvae of *M. dobula* are still undescribed. In the present section, therefore, it is necessary to use whatever indirect evidence is available and to proceed largely by analogy and by an examination of likelihood.

The weight of evidence indicates that spawning occurs at sea on the coast, during or at the end of the autumn migration. The evidence is that the fish at this time are ripening and ripe and that these stages, with few exceptions, are taken only on the coast. The spent stages are reported on the coast and in this investigation have been found there only. The nature of the migrations and the relationship to spawning stages are discussed in Sub-sections (vi) and (ix). An act known as "ringing" is frequently observed by fishermen among the mullet in schools near headlands; they move around in a ring and by some observers are reported to travel around with their snout down and their tail up - at an angle of 45 degrees. This act is said to be a spawning act (and was described as such by Roughley (1916) in head waters), but this has not been corroborated by others. At present it seems to be only special schooling behaviour which precedes migration. The massing of fish into schools is a typical spawning behaviour among fish, and it seems reasonable to assume, until positive evidence is otherwise available, that the schooling of mullet is the same, and that spawning occurs whilst they are in their schools - that when they re-enter the rivers and are no longer in schools their spawning has been accomplished; this opinion is held by Mediterranean workers.

It should be remembered that schooled mullet are observable in the rivers prior to migrating and on the coast whilst migrating, and that mullet in the dispersed phase are known to be present but are not seen in great numbers.

As a converse to this assumption many observers consider that spawning occurs at the heads of rivers, after the autumn migration: that is, that the fish school together, travel to sea, and then disperse to spawn in the shallow water of small creeks. The only precise account of this method of reproduction has been given by Roughley (1916) but it has not been corroborated by any other investigator, though Roughley's observations of the spawning behaviour of the fish, the nature of the egg deposition, etc. are described with a wealth of

circumstantial detail and present a picture of phenomena so conspicuous as scarcely capable of being readily overlooked.

An account was given by C. M. Breder (1940) of what was taken to be the spawning act of *M. cephalus* on the eastern coast of America. This was observed in a mangrove creek in shallow water. The sexes were identified by differences in colour and sheen, and in the "spawning act" a number of males were seen to huddle close to a single female. No eggs were recovered but spent fish were caught in the same locality. A similar type of activity was observed in the present investigations in the same kind of locality. In June 1940, whilst at Tewantin in Queensland, the author observed mullet in the mangrove creek which connects Weyba Lake to the Noosa river; the situation is about two or three miles from the ocean beaches. The mullet were darting about just below the surface; in particular, smaller fish, which fishermen present claimed were males, could be seen darting at the larger fish (described as females), and striking flank against flank. The fishermen asserted that this was a spawning act. However, some of the fish were netted for tagging (Experiment 26, Table 15) and an examination made of some females; the males were discovered during the tagging operations to be ripe, but none of the females were running ripe. A plankton net was hauled as soon as possible, but no eggs were secured. This therefore, seems to have been merely pre-spawning behaviour.

C. M. Breder at the same time (l.c.) states that local fishermen were of the opinion that spawning occurs on the ocean beaches, and fishermen here have expressed the same opinion. One man has stated that he has observed spawning on the beaches around the islands in Moreton Bay and the total effect of all evidence seems to support this interpretation. Workers in the Mediterranean hold this view also.

An analogy may be drawn between the spawning behaviour of the silver bream (*Roughleyia australis*) and the presumed behaviour of *M. dobula*. The former travels to sea in spawning condition, no ripe females can be captured by net but ripe males are common; running-ripe females may be caught from sea walls and ocean beaches by rod and line. This was done at Caloundra where male and female fish in running ripe condition were taken and artificial fertilisation performed, it was then possible to observe the preliminary stages of development and to describe the egg. In plankton net hauls made later it was possible to identify these eggs and to follow development into larval stages by overlapping catches of successive stages, and by rough aquarium work. To reproduce this sequence in mullet is impossible, because *M. dobula* cannot be caught with rod and line; nevertheless, there is a plausible similarity between the two. In addition, eggs and larvae which appear at least to be Mugiloid were taken at Tewantin, in the course of the same work; description of these is postponed until a more precise identification is possible and until the details of spawning can be confirmed; announcement is made here because of the urgency of the present report.

The final evidence is that small fish, which must be assumed to be post-larvae, have been said to appear in the northern rivers, in particular in the Noosa river, in large schools in August and September, and to lie in the estuary until summer when they are no longer noticeable. At first appearance the fish are said to be about an inch long, that is, about 2-3 cm. which would be the appropriate length for the post-larvae of eggs spawned in June-July at which

time the ripe fish are present in the Noosa River. Again, the O-group are taken within a few miles of the entrance to rivers, and this also conforms with the view that spawning had taken place on the ocean beaches.

In addition to determining whether spawning definitely does occur on the ocean beaches, there remains a problem of whether spawning occurs on all the ocean beaches up the coast, progressively with the spawning migration, or whether it is confined to a definite area in the north such as among the mangrove islands of Moreton Bay and nearby. That location corresponds in character to the supposed spawning area on the Florida coast. The relationship of this question to growth rate, etc. is discussed above (p. 45).

Accounts have been given by Cunningham (1890, 1891, 1896) Roule (1917), Sanzo (1930), Belloc (1938), and Ehrenbaum (1905-09) of mullet eggs and larvae. The eggs are generally small (less than 1 mm.), pelagic or semi-pelagic, pigmented yellow; they hatch quickly (48 hours, Belloc), and the larvae, which are pigmented, are pelagic. Such characters as these make it possible that the eggs and larvae could be distributed to southern waters by drifting.

(viii) Post-larval Life:

Post-larvae appear (vide p. 53) in estuaries towards the end of winter. A similar movement of post-larval *M.cephalus* in Egypt, one month after the commencement of the spawning migration, is reported by Faouzi (1937). A similar report was made by Jacot (1920) for the American *M.cephalus*; Jacot reports that at this time these fish feed upon plankton in the course of "schooled" movements about the shores of these waters, and that when the fish change to become bottom dwellers they change their mode of feeding to the adult type. Similar evidence on feeding is not available here, but the pelagic existence and the change-over to demersal towards the end of the year (that is, in summer) are characteristic.

In the second year the fish have assumed demersal life and move away from the sea up into the lakes and the higher waters of the rivers; this is continued until summer in the third year, but may be interrupted by the minor migrations referred to in Sub-section (ix). Their spawning migration occurs at the end of their third year and after this the fish retreat to relatively inaccessible waters (vide Hubbs, 1921) until they begin again to school for their second spawning migration. Because of this the lake and river fishery must operate upon immature fourth year fish and upon third year fish, all of which are immature, until either a flood or late summer causes the large fish, 4 years and older, to school.

(ix) Migration, Tagging Experiments:

Frequent reference has been made to the various migrations of mullet. These movements apparently play a major role in the life-history of these fish, and it was important to discover more about which fish were involved in the movements, about direction and extent of movements, etc. To this end tagging experiments were conducted.

(a) Tagging Experiments:

The various releases are listed in Table 15. They were in two series, of which the first was made during 1938 for New South Wales State Fisheries, and the second for the Council for Scientific and Industrial Research. In the first series an opercular tag consisting of silver clip and celluloid disc (as used by Godsil for tuna) was used. Only 4 returns were secured from 880 releases, i.e. less than 0.4 per cent.

In the second series a simpler opercular tag consisting only of a metal clip bearing a number and the letters C.S.I.R. was used. This series has been more successful, 70 returns in 1533 releases representing approximately 4.5 per cent.

At tagging, length of the fish was always taken. In the releases 1 to 15 weight also was taken, but since this was found to delay operations and to lead occasionally to injury of the fish, it was abandoned in subsequent operations. One or two scales were removed from each fish in releases 15 to 19 and 22 to 39; the failure to collect scales was in some instances due to incomplete tagging teams.

In almost all cases the recovered fish were quite unharmed by the simpler type of tag, there being no sign of corrosion of the gill-cover. A few fish were tagged and placed in a large pond for observation; they could be seen swimming about, and the movement of the gill-covers could be watched: the movement appeared to be quite normal and quite equal as between tagged and the non-tagged sides; there was no sign that the tag caused the fish any discomfort.

The recoveries are listed in Table 15. In a few cases information upon circumstances of recapture was not given (C.S.I.R. 844); in other cases part only of the information was supplied, and in many cases the length measurement appeared suspect. It was consequently thought advisable to make an appeal for the despatch of recaptured fish to this Laboratory, where measurements might be made according to the same technique as that used when the fish were released.

(1) Recoveries and Fishing Intensity: A 0.4 per cent. return was obtained for the first series using the clip and disc type of tag; this small return might be taken to mean that only few of these fish were recaptured, but in the light of the difficulties reported by Godsil (1938 a & b) in using the tag on tuna, and also by comparison with the return secured in the use of the much less conspicuous tag consisting of only a clip, it must be assumed that the tags were lost from the fish or that they caused a heavy select mortality among those fish, or that both processes operated to prevent the recapture of the fish. In the second series, where the simpler type of tag was employed, a much higher return was secured. Over all, the return to date is 4.5 per cent. but from the operations at Ballina the return is now 8.9 per cent. and from one Port Hacking experiment there has been a return of 17.4 per cent. in six months. It is probable that these "returns" figures do not correspond to the actual recaptures, for in any work of this kind which depends upon the discovery of recovered tags by fishermen and others in the trade, and upon their co-operation in sending the tags to the tagging authority, there is always evidence (as well as *a priori* reason) for supposing that a

number of tags are recovered which do not find their way to the research workers. Reports have already been received, during the work, of tags neglected or thrown away. On the other hand, it is tempting to regard the efficiency of netting operations in securing recaptures of tagged fish as representing their efficiency in capturing all fish commercially. Accepting the actual returns, we find a fishing rate in the north of about 9 per cent. per annum, and of about 35 per cent. on the mid-coast. About 5 per cent. of the fish tagged at Ballina were returned within a month during the course of travelling season operations; this can mean that the operations remove 5 per cent. of the fish which travel. Again, the returns from the Port Hacking release may indicate that the river fishery captures 17.4 per cent. of its stock.

Although these figures are quite incomplete and do not lend themselves to any conclusion, they do indicate the possibilities of this method. It should be possible by an extensive tagging programme (backed by an energetic propaganda programme), in collaboration with an efficient statistical system, to secure accurate estimates of the fishing rate of the two phases of the fishery, and also the rate at different localities (see Graham, 1938). Finally, use could be made of the "Lincoln" Index (vide Jackson 1936, also 1939, and 1940) in estimating the population of the entire coast. Following tagging operations the population may be estimated equal to:-

$$\frac{\text{Total marked} \times \text{total caught when recapturing}}{\text{Recapture.}}$$

(2) The Types of Fish that have been Tagged: Most of the fish tagged were unripe, some being immature and some recovering or ripening; the fish released in experiments 20, 21, 26 to 28, and 35 to 39 were exceptions to this, for the males in these groups were running ripe. With the exception of releases 1, 20, and 21, all the work was done in lakes, rivers, or estuaries, in almost every case on river fish. There was no question that the fish being tagged were not river fish; but in some cases they were captured as sea fish, and those other cases where tagged fish were recaptured in waters north of their release locality are sufficiently conclusive in determining the debate upon the origin of the sea fish (see p.12). Two cases are of especial interest. The fish tagged in the Nicholson River in Victoria were large typical river fish with dark slimy backs, etc.; according to local fishermen those fish never migrated; also, according to New South Wales fishermen, none of the fish on their coast came from Victorian waters; however, one tag (of only 20) has already been returned, having been recaptured some 450 miles north of the Nicholson; this seems to be a crucial piece of evidence. Again, the fish of releases 20 and 21 were typical river fish, caught, however, at the mouth of the Richmond River as they were leaving that river; the males were running ripe and the females were full-roed but not ripe; of the returns from this group one was recaptured within a month in the Richmond River near its mouth and three in the same time about 50 miles north; this is an important piece of evidence on the point above referred to and on the nature of the migration.

Moorhouse in 1931 labelled 3 in. - 18 in. mullet with numbered rustless steel labels. The fish were tagged in the Nerang and Coomera Rivers and Moreton Bay. He reported

(1932) - "Some 2,500 fish were labelled, but only two have been taken again. These were both "hardguts" (the name given by fishermen to those mullet that are taken during the November floodings of our rivers). It would appear that these mullet, which fishermen had thought had carried out an extensive migration, are really fish from our local rivers, so that their migration has been of very limited extent." It is not clear what the last sentence means but if it intends to convey an idea that the immature fish of Moreton Bay do not participate in the general movement of mullet of this coast then it must be said that that is a premature conclusion based upon inadequate evidence; premature because there does not seem to have been a very long interval of freedom, and inadequate because two fish alone is a small return, and two in 2,500 indicates some fault in the system of tagging or of securing returns (especially in view of the rate of returns in the present work).

(3) Direction of Movement: It will be seen from Table 18 that in all cases movements were northwards from the tagging locality, or there was no movement away at all.* That is, there was no southwards movement. In 43 cases there was northwards movement, and in 29 cases there was no movement away, but in some of these there was definite movement within the water system; finally in two cases there was no information upon locality of capture and movement was, therefore, not known.

(4) Extent of Movement: Of the fish which moved away from the tagging locality, some made extensive migrations. New South Wales 304 travelled at least 100 miles, C.S.I.R. 2762 at least 250 miles, and C.S.I.R. 2794 at least 450 miles; others travelled 40, 50, and 60 miles. These estimates are of the direct distance between points of release and recapture. Until steps can be taken to secure the second release of fish (after measuring and noting the number), the extent and nature of movements between first tagging and final recapture must remain open to speculation: the important question which rests here is whether individual fish make successive movements year by year, continuing northwards, or by possibly surreptitious southwards movement during winter or spring, remain within a well-defined district. If the first possibility were true then there should be no older fish in the southern waters; on the other hand the evidence of the latter possibility is yet wanting (but see later section p. 60). Alternatively the fish of southern waters might postpone their spawning migration until the fourth or even a later year, but evidence of this type refers principally to fish of northern waters (vide Table 16, C.S.I.R. 1921, 2259, and 1750). Finally, although C.S.I.R. 829, of a series released at Ballina, seems to have escaped the nets at Tweed Heads and to have travelled further than the others in the group and thus to have provided evidence that in certain cases at least the distance travelled (by tagged fish before recapture) may not be as much as the fish could have travelled, nevertheless such returns as have been secured show that the length of migration in each year by individual fish can vary considerably.

(5) Time of Movement: New South Wales 804 was tagged in February, just before the spawning migration: it was at least 3+ years old, and it moved in the month following its release. C.S.I.R. 1606 was tagged in December and recaptured in the following June. It could have moved in the normal time (January to March) and have been in the Myall

* C.S.I.R. 2735 was recaptured in its river of release two weeks after release and was set free again.

Lakes some months before recapture, or it could have made a belated migration. C.S.I.R. 2762 and C.S.I.R. 2794 were tagged in May just before the travelling season of this region, and travelled northwards within two months. C.S.I.R. 849, 812, and 865 were tagged at the commencement of a spawning migration which was not interrupted by the tagging operations; C.S.I.R. 870 of this series turned back at once, however, C.S.I.R. 829 also of this series, continued north, escaping the netting operations by which the other three were recaptured, and reached the Noosa River where it was captured six months later; it could have turned back with C.S.I.R. 870 and travelled later: there is no way yet of deciding upon this point. C.S.I.R. 1750 was tagged in January 1940 and was recaptured in July 1941, it could have moved north in the travelling season of 1940, or that of 1941.

Of the large group which travelled from Port Hacking to the Hawkesbury River, where they were caught again, two (C.S.I.R. 890 and 1092) were tagged six months before the others; it seems possible that they had remained in Port Hacking through the spawning season of 1940, and moved in the winter of that year with the others, which were tagged in autumn of that year. Even if the movement of the others (that is, those tagged in autumn) had taken place at once, it would have been belated in relation to the spawning movement. It is probable that the movement of the fish of this group can be considered as evidence of a non-spawning migration, especially since most of the fish were 2+ and immature.

(6) Proportion of Movement: It has been suggested that only a small proportion of the stock travels northwards in each year. This proposition cannot be examined completely on the basis of tagging returns, for just as the return percentages cannot be used to indicate fishing intensity, they also cannot be used to indicate migration proportions.

However, the proposition cannot be denied and, if it were true, then any estimates of rate of fishing in the travelling season would be rates upon only proportion of the total population - a point which would need to be remembered in designing control measures. On the other hand, while 29 of the tagging returns were made from fish which had not migrated, 8 of these were made within a few days and were almost certainly casualties, 17 were recaptured before the travelling season following release and only 4 were tagged before a travelling season and recaptured after; that is - 4 positive non-travellers against 43 travellers.

It has also been suggested that the fish might move out to spawn and then return to their home river. To test this it will be necessary to tag travelling fish on ocean beaches somewhat remote from rivers; it has not been possible yet to do this in spite of many efforts to this end.

(7) Growth Rate: The reported lengths at recapture were in many cases less than the length at release. This must be due to faulty measuring, at either release or recapture or at both. Every precaution is taken at tagging to secure accurate and standardised measuring; also a request has been issued for the despatch of recaptured fish to this Laboratory. If the discrepancies persisted after these measures then it would be necessary to assume a detrimental

effect of tagging upon the fish. An examination of Table 16 will show that the data on growth-in-interval-free is as yet too irregular and scarce to be of much use as corroborative evidence of the scale reading technique.

C.S.I.R. 2259 provides some interesting information in connection with scale reading, and is referred to in the appropriate section.

(b) Spawning Migration:

The schools of travelling mullet appear on the south coast (Twofold Bay region) at the beginning of the year. This may be as early as February although the main movement is in March and April. The movement continues, intermittently, along the whole coast for the next three months, ending in Queensland some time about the end of July. The appearance of continuous movement is produced by migrations of independent schools and is probably more apparent than real. The fish congregate in schools in the rivers and lakes and prepare for their migration, this being, apparently, a behaviour reaction to internal rhythms. The embarkation upon the migration appears to be in response to heavy winds in the south and west quarter of the compass (see Tosh, 1903). In general the break of autumn weather is taken to indicate that the schools will appear. If the winds are effective over a large extent of coast in which the schools are ready to travel, there can be simultaneous movement over the whole of that part of the coast. At times, however, only isolated schools move. A "travelling" season may be of short or long duration depending upon the rate at which the migration is made as well as upon the numbers of fish available to move.

At each river mouth it is possible to identify two types of fish: some which are dark in colour and slimy and are embarking upon their first movement, and others which are free of slime and are silvery and metallic blue upon the back. The former move directly out along the northern shore, the latter enter along the south shore, move across the river, and pass out along the north shore, at once or after a short interval.

The schools at this time of the year may consist of immature fish, but in general they consist of mature, nearly ripe fish. Males ripen first, and running ripe individuals may be obtained from these schools even on the south coast. The females in these schools are generally approaching ripe; although such individuals can be taken on the south coast the greatest concentration of them is found on the north coast. Spent fish are reported in New South Wales on the north coast but have been seen in the present investigation only at Yeppoon, Queensland, where, however, the capture was made in one of the beach traps used there: that is to say, appropriate methods might catch such fish on the New South Wales coast. Frequently the males outnumber the females in these schools, and the males are also often a year younger than the females with which they travel; the sex differences are often remarked by the fishermen.

The extent of these movements has been investigated in the tagging operations reported above, but as yet it is not possible to state the limits of individual movements in each season. The main problem relates to spawning and to whether the fish of the far south coast, in their first year, move to about the Hawkesbury River, spawn in the surf thereby, and then enter the river, or whether, alternatively, such fish as have been seen to enter these rivers and are thought not to

leave again in that season really remain there or slip out and continue to a spawning area in the north.

When floods occur the travelling fish keep wide to avoid the flood waters. Similarly flood waters drive unripe fish out of rivers during other times of the year.

(c) Movements of Immature Fish.*

The movements of two-year old fish are quite well known and evidence of them has been collected in tagging experiments. These movements may occur at the same time as the spawning migration or, apparently, at almost any time of the year, although the major period for such movements is summer. It is thought that these movements occur mainly in relation to westerly winds, but whether this is true, or what the relationship might be, it is difficult to discover. In the case of these fish, as of the older fish, there is no evidence of southward migration.

No information is yet available on the movements of first or second year fish.

(d) Non-spawning Migration:

Referred to above as a movement of unripe fish due to floods. Jacot (1920) postulates a northwards movement (which would correspond to a southwards movement here) of American *M. cephalus* in deep waters during winter - spring.

(x) Feeding:

Mullet (*M. dobula* at least) appear to be bottom feeders, making use of accumulations of detritus in lakes and estuaries. No discrete identifiable material has been found in the stomach of any mullet in the course of the present investigations. Stomach contents have consisted only of slime; the fish can be observed nosing in mud, apparently searching for food; Gunther (1861) gives the following account of their feeding - "the fishes of this genus feed on organic substances which are mixed up with the sand and mud; a considerable indigestible portion of the latter is swallowed; and in order to prevent larger bodies from passing into the stomach, or substances from passing through the gill openings, these fish have the organs of the pharynx modified into a filtering apparatus. These fishes take in a quantity of sand and mud and, after having worked it for some time between the pharyngeal bones, they eject the roughest and indigestible portion of it." Although, as indicated above, this report can be confirmed in so far as it refers to feeding habit, nothing yet can be said as to what materials are actually ingested and what use is made of them. Whether algae or plant and animal detritus form the major part of the food cannot be said.

Travelling fish are almost invariably empty gutted when examined; the gut of a travelling fish, heavy in roe, is no more than a compact mass of tissue containing only a small quantity of viscid fluid. Presumably feeding ceases when the fish move into the sea; no sea-food has been noted at any time, and its absence is assumed to support the idea that feeding ceases at sea. The significance of this probable cessation of feeding (Jacot, 1920) is discussed in the section above on the interpretation of scales.

* Vide Arne (1938) and Roule (1915 a and b, 1916) by whom these movements were discussed, apparently with the thought that it might be a second spawning migration.

(xi) Parasites and Abnormalities, Earthiness:

In so far as parasites, disease, etc. may cause mortality among the mullet or, as is especially so in relation to "earthiness", make the mullet uneatable, consideration must be given to their nature and incidence. Actually apart from the problem of earthiness no considerable loss occurs and the phenomena are not of great importance.

(a) Parasites:

A parasitic copepod is quite often found attached to fins; it is easily removable and does no harm.

(b) Hermaphroditism:

Hermaphrodite roes in otherwise apparently normal fish are not very rare, one or two being found in each season, but obviously such cases as do occur cause no great loss.

(c) Wounds from Sharks:

While wounded fish do occur in the catches, they are sufficiently rare to be negligible.

(d) Earthiness:

Earthy mullet appear to be quite normal, but when filleted a strong earthy odour becomes apparent, or, in some cases, this earthy odour apparently is not noticeable until the flesh is being cooked when it becomes very noticeable and overpowering, and is said to "fill the house". Clearly, when the odour is noticeable in the market, the fish are unsaleable, or if they are sold a loss of goodwill may occur, in addition to the flesh being in any case uneatable. In some years a considerable quantity of this fish is caught and considerable bother is caused. The problem was superficially examined in relation to pollution problems in the Clarence River by Kesteven and Rochford (1938). At that time there were many complaints of muddiness in the river and blame was laid upon the dredges operating in the upper reaches of the river; at the same time this muddiness was said to be the cause of the prevalence of "earthiness" in the mullet of that river. However, the first report of earthiness in mullet was made in 1915, and according to verbal reports the problem existed some time before that date; this history is considerably longer than that of the alleged dredge nuisance; also, as shown in 1938, the limits of incidence of earthiness do not coincide with the limits of pollution, as supposed to be caused by the dredges; finally, so far as could be determined in 1938, the dredges could not be held responsible for the alleged pollution. Although fishermen asserted that the earthiness was due to feeding upon mud by the mullet, this does not seem reasonable since all mullet are mud feeders (see above p. 60), and also earthy mullet are frequently quite empty gutted.

The features of the present case greatly resemble a case reported from Scotland by Thaysen (1936). This report may be quoted extensively. "Salmon caught in one of the richest salmon rivers of the Kingdom had been found contaminated with an "earthy" taint which was particularly noticeable on boiling and which rendered the flesh of that fish quite uneatable." Several possibilities had been examined by previous writers; the possibility that ingestion

of mud was responsible was ruled out; Thaysen explored the possibility of Actinomyces being responsible. In the first place he examined the metabolic product of Actinomyces. This gave off a pungent "earthy" odour, and the substance was soluble in water and volatile in steam. This substance "when dissolved in water in concentrations as low as two parts in ten million imparts to the water a pungent Actinomyces or "earthy" taint which is particularly noticeable when the reaction of the water is maintained on the alkaline side of the neutral point." The existence of an excessive contamination of an important salmon river with odour-producing Actinomyces was established. This contamination and the resultant pollution of the water with a pungent "earthy" taint was restricted to the tidal part of the river where decaying organic matter was abundant. Thaysen next examined the possibility of this substance being absorbed from the water through the gills and being distributed through the body by the blood and being, finally, accumulated in the muscular tissue. He established that an earthy taint could be imparted to the flesh of trout by this substance in water, that the taste of such flesh resembled that imparted by mud rich in Actinomyces, that the taint does appear to be acquired through the gills and finally that the taint could be lost from the fish if they were allowed a few hours swimming in clean flowing water.

It will be seen that the general circumstances and features of the two cases are very much alike, and it is assumed that Actinomyces may be the responsible agent in the present case. If research showed that this were true then, unfortunately, there would be no practical means of preventing or removing the taint; the only practicable measure would be a prohibition against fishing in contaminated waters. Such a prohibition would be decided upon following research to show the limits of distribution of the Actinomyces and of the conditions favourable to its propagation, and would be effective for so long as such distribution and conditions persisted. Thaysen's work shows that the distribution of Actinomyces in rivers is limited to a definite region, and the incidence of earthiness shows that the condition does not last many months; this means that the situation is by no means hopeless, and moreover, the fish from such tainted regions apparently become clean again either because of migrating to sea or because the river becomes flushed out with flood waters.

(xii) Summary of Biology:

The biological work reported here may be summarised as follows:

1. The present investigation has been confined to the bull-head mullet *Mugil dobula* Gunther, which has in the past been equated to *M. cephalus* Linn.
2. As yet there does not appear to be any raciation although it is probable that the three stocks of western, south, and eastern Australia remain distinct and do not mingle.
3. Weight is an exponential function of the length of the fish, but there are seasonal variations in the relation of weight to volume and of volume to length.
4. The normal condition factor $k = \frac{W}{0.01L^3}$ fits mullet data well enough for average values, but it has

been modified to $k = \frac{W}{0.0037 TL^3} + 0.0566 bTL$

(Where $b = b' TL \times b'' TL$, and b' & b'' are portions of TL representing the diameters of the trunk section) in order that changes in volume per length and weight per volume (density) might be studied.

5. Use has been made of scales in the determination of age. Confirmation of the reading has been obtained from modal lengths and from calculated lengths.
6. The scale, which is ctenoid, shows circuli separated into zones by "lines". The lines are interpreted as being formed whenever the fish cease feeding; such cessations of feeding can be shown probably to occur regularly at spawning time whether the fish migrate or not, and irregularly when any of the minor migrations are performed.
7. *M. dobula* grows to about 15, 23, 32, 40, and 48 cm. in the first five years.
8. *M. dobula* matures at the end of its third year at a length of about 33 cm. for the females and about 31 cm. for the males.
9. Each fish matures rapidly, that is, the gonads remain undeveloped until within about two months of spawning; the same obtains for recovering fish.
10. Overall the sex ratio is approximately two males to one female, but considerable preponderance of either sex may occur in the travelling schools.
11. An ovary may contain up to 2,500,000 eggs. The ripe roe may be 10 per cent. of the total weight of the fish; an ovary as much as 20 per cent.
12. It is not known whether the spawning occurs only at the northern end of the spawning migration (and therefore in May - June) or progressively during the course of the migration (and therefore February-July).
13. The spawning act has never been observed; none of the many detailed accounts of spawning conforms with known facts. It is assumed here, until fuller information is available, that spawning occurs at or near the mouths of estuaries in the surf zone.
14. There is reason to believe that the egg is pelagic and hatches within a short period.
15. Larval development is unknown.
16. Post-larvae of 2 cm. are reported in the estuaries at the end of winter. Subsequent post-larval and juvenile life is spent in the estuaries.
17. The juvenile fish are still within a few miles of the estuary at the end of their first year, but after that they move further up the rivers or lakes and spend their second and third year there; they possibly make a migration in this period.
18. The migration of *M. dobula* was examined by means of tagging experiments and was shown to be chiefly northerly in direction but other evidence compels

the assumption that there is a southerly movement at some time in the life of the fish.

19. The major migration is a spawning movement in late summer and autumn; there are irregular minor movements dictated chiefly by weather conditions.
20. Mullet are bottom feeders, taking mud and slime from which apparently organic material is removed and ingested.
21. Evidence is given to show that earthiness may possibly be due to contamination from Actinomyces.

4. CONDITION OF THE FISHERY.

Following a general description (in Section 2) of the fishery and its control, an account has been given (Section 3) of the present knowledge of the biology of the mullet *M. cobula*. Upon the basis of that account a more confident approach can be made to an examination of the present condition of the fishery. A fishery may be in a condition of under, optimum, or over-fishing, and the decision as to the condition of a particular fishery should be made upon economic and biological grounds. In the majority of cases where an examination has to be made of the condition of a fishery, the proposition resolves itself into "does depletion exist, if it does to what extent is it present, and to what is it due?" The twofold examination has been made of the Australian mullet, and although the conclusions reached are limited by the inadequacy of the data, fullest use has, nevertheless, been made of available material and, in any case, such limitations are of degree and it will be clear that the conclusions are, in the main, sound enough to base the recommendations for control upon them.

(i) Economic Evidence:

No statistics are available from Western Australia or from Tasmania. Statistics from South Australia are for 1937-39; these give catch of species month by month. Fairly detailed statistics are available from Victoria for 1910-39, giving catch of mullet of two kinds from each important fishing centre for each months.

From New South Wales detailed figures on catch of mullet from each locality for each month since January 1937 are available; these figures are comprehensive, being compiled by Fisheries Inspectors on the basis of returns furnished monthly by fishermen and checked by returns made by carriers. Before 1937 figures on total quantity of fish from each locality are available since 1910, and with them there are figures on gear, boats, and men. It is possible, if certain justifiable assumptions are permitted, to make use of these data in the present study; this is indicated below.

Statistics are available from Queensland since 1922: those from 1922 to 1934 give total catch* of mullet for the State, those since 1934 give catch month by month.

* The data are actually market handlings but, in effect, for estuarine fish, they must nearly represent total catch for southern Queensland.

(a) Geographical Distribution of the Catch:

An indication of the region in which mullet is caught, and of the relative importance of the different fishing centres, is given in Fig. 9. The catch for twelve months at each of the important centres is given in Table 17. The figure and table show that the greatest catch is made in the area between Newcastle and Brisbane, with Clarence River as the locality of greatest catch and probably as a centre from which other areas receive stocks. In an approximate fashion the Table 17 and Fig. 9 indicate the relationship between magnitude of area of brackish waters and magnitude of catch - and, consequently, magnitude of stocks. If the localities are placed in order of relative size of catch it will be found that this roughly corresponds to the amount of brackish waters available. There are some exceptions, such as Byron Bay, but the catches at those places are derived from the rivers which lie immediately south of them.

(b) Monthly and Seasonal Distribution of Catch:

The two-phase existence of *M. dobula* and the corresponding fisheries shows quite clearly in the available statistics. Figs. 10(a)-(c) show monthly catches (or market receipts) for Victoria, N.S.W., and Queensland. In each of these there are a number of peaks occurring at approximately the same position. The Victorian graph shows peaks from May to July, New South Wales has an extensive maximum from mid-January to mid-May, and Queensland has a major maximum from mid-April to mid-June with minor maxima occurring in February, March, or April. These maxima are due to additional catches, made in those months, of sea mullet, for it will be seen that, apart from the additional minor maxima in Victoria and Queensland, these maxima correspond to the times of the spawning migration. In Victoria during the period 1918-24, there was a peak in January-February which was absent during 1931-38: the peak of the earlier period is quite consistent with the statistics of the other States and the interpretation which is being placed upon these maxima. The absence of January-February peaks from the 1931-38 period could mean that fishable schools of spawning fish no longer appear in those waters: this would be consistent with other evidence of general depletion of these stocks along this coast. However, it should be borne in mind that the Victorian monthly catch averages about four thousand pounds, which is 1/140th of the average monthly catch in New South Wales, and in any case four thousand pounds is no more than can, in the travelling season at least, be captured by one team of men at one shot. Such figures as these indicate a casual fishery subject to occasional hazards of occurrence of the fish; lying on the southern boundary of this area of distribution Victoria may be expected to have a fishery subject to chance fluctuations; but, in addition, if any process of depletion should occur there would in effect be a shrinkage of the area of distribution, a withdrawal from the marginal areas. The maxima of May and July-August however are difficult to interpret. It has not yet been possible to make any biological analysis of the catches at these times.

In the New South Wales fishery there is a sustained maximum, which beginning in January continues until about June. Since New South Wales occupies the major part of the mullet distribution, the effect of the heightened fishing rate which develops during the travelling season is maintained during the operations along the entire coast.



Fig. 9 - Distribution of commercial catch on the Eastern coast of Australia during the years. It should be noted that the catch at any locality is represented approximately by the area of black lying opposite that point.

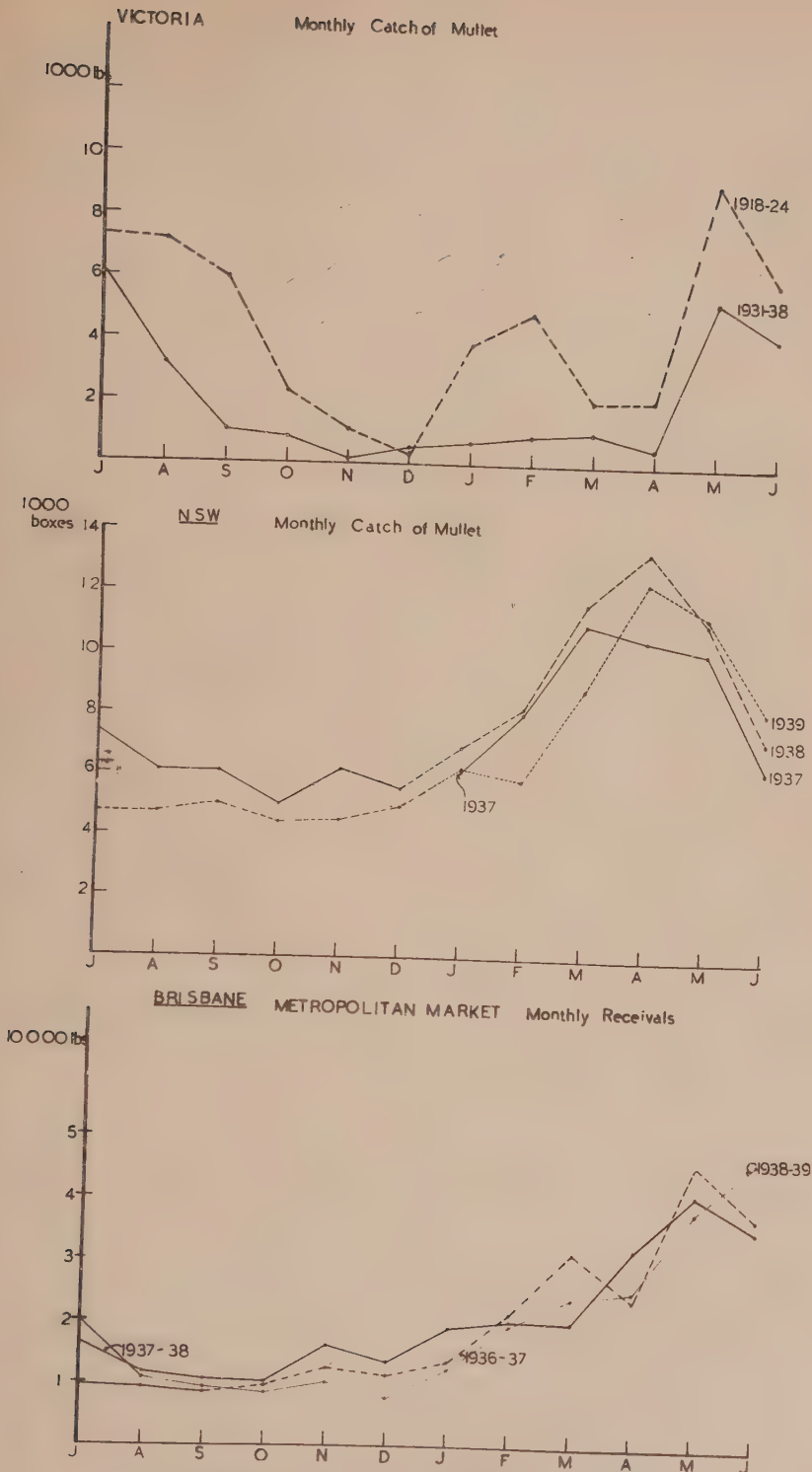


Fig. 10 - Average monthly catch of mullet for -

a. Victoria (1918-24, 1931-38)

b. New South Wales (1937-39)

c. Queensland (1936-39).

The Victorian figures refer wholly to *M. dobula*; in the other States there has been no separation of catch of other species from the catch of *M. dobula*, however these figures also refer principally to *M. dobula*.

Queensland has a season in May-June-July; it is a continuation of the New South Wales season, and, actually part of the mullet consumed in Brisbane is drawn from northern New South Wales. The extra maximum in February 1940 consisted of fish caught at Tweed Heads and Wynnum in that month. These were probably hardgut and mangrove mullet, possibly engaged upon a summer migration which is fairly common for such stock.

As indicated, these peaks are taken to represent the increased fishing results in the travelling fish season, and the graphs may therefore be taken to indicate the relative importance of the two fisheries. In column 2 of Table 17 (a and b) the catch is recorded for the months of this season; these are placed as April, May, June for N.S.W. and as May, June, July for Queensland. It is held that in any year the season for each State is covered approximately by three months. Since the river - and lake - fishing does not cease at these times, and since there is no division of market statistics to correspond to the two phases, a precise estimate of the catch of the two phases cannot be given. However, the opinion is held by Mr. R.F. Thompson of the Brisbane Fish Board that one would have a good estimate of the quantity of sea-mullet by taking 80 per cent. of the catch of the three months of the sea-mullet season. In column 3 of Table 17, 80 per cent. of the figure in column 2 is given as a percentage of the figure in column 1. Again, in column 4 of that table, 100 per cent. of the figure in column 2 is given as a percentage of the figure in column 1; this was done in case 80 per cent. of a three-month season was considered an illiberal estimate of the sea-mullet catch. This table shows that although the fishing in the sea-mullet season is at a higher rate than for the remainder of the year, it does not remove as great a quantity of fish from the fishery. This is true, in spite of a greater vulnerability of the fish in this season and a seeming greater mobilisation of men and gear at that time. Moreover, the fish taken in the travelling season are almost invariably of older age groups than those of the remainder of the year (vide p. 12) and this means that not only is the mass of fish smaller but also that a smaller number of individuals are removed in this phase of the fishery. On the other hand these larger fish taken in the beach fishery are, at the present time at least, the stock upon which it would be preferable that the fishery did not operate.

Again, in columns 5 & 6 of Table 17 the total mullet catch, and the sea-mullet season catch at each locality, are expressed as a percentage of the total mullet catch, and the total sea-mullet season catch for the State. It will be seen that there are no great differences between the respective percentages for any locality; that is, any locality which figures importantly for sea-mullet is important also for the remainder of the year, and this is taken to be further evidence of the essential unity of these stocks and of the fishery which operates upon them.

(c) General Trend of the Fishery and Estimates of Effort:

Victorian Statistics, available from 1911, show a great peak in 1918 (see Fig. 11) and since then an irregular decrease. The authenticity of the 1919 peak is vouched for by the preceding and following high catches. The questions which prompt themselves are: (1), what was the history of the fishery prior to 1911; (2), are any of the

fluctuations due to variations in the number of men engaged; (3), to what extent are the fluctuations due to chance variation in the behaviour of the stock at this edge of the distribution of *M. dobula*? The answer to these questions is to be found only in fuller statistics.

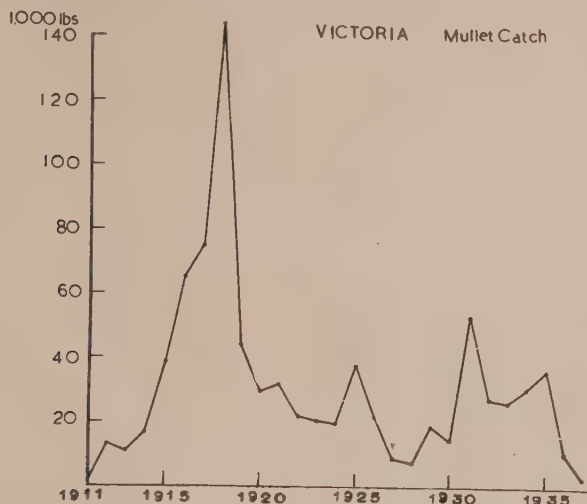


Fig. 11 - Annual catch of mullet in Victoria.

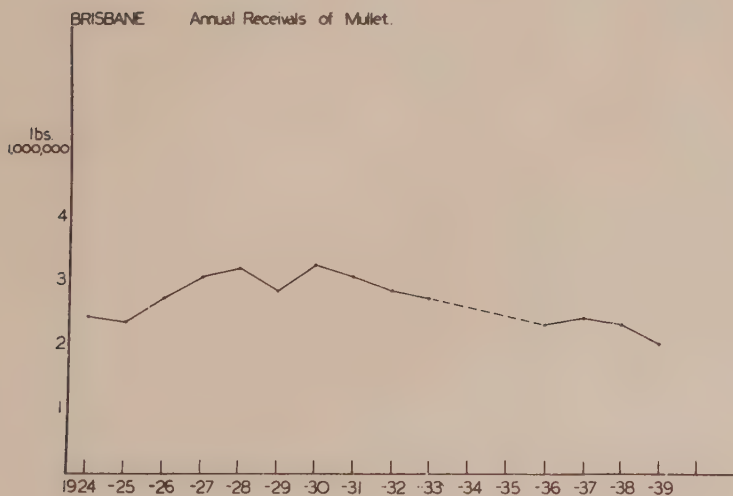


Fig. 12 - Annual catch of mullet in Queensland.

For New South Wales there are data on the total catch for the whole State and for each locality, and also on men engaged, boats in use, and value of boats; these data are available since at least 1900. It is assumed that (a) for any locality or for the whole State, it can be shown (a) that the species composition of the catch has remained fairly constant, and (b) that mullet figure largely in that catch, then the data in such cases can be used in an estimate of the condition of the mullet stocks among the many other estuarine species. The catch of fish taken on the coast of New South Wales consists principally of the "estuarine"

species including mullet, blackfish, bream, whiting, and others; there are in addition the fish taken on lines such as schnapper and tiger flathead; to these an important addition is now made by the salmon caught on the south coast for canning. Until the trawlers, catching demersal fish, began to operate, the New South Wales fish markets received only the fish of the types listed above. The trawled catch, however, does not appear to have deterred the onshore fishermen. Table 18 shows some proportions of mullet catch to total catch for a number of different years. It will be seen that for the Hastings River, the catch was 40-50 per cent. mullet in odd years, 1905-1910; and was 55 and 61 per cent. in 1937 and 1938; New South Wales mullet catch was 60 and 58 per cent. of all species in 1937 and 1938; Queensland mullet was 52.5, 52.1, and 47.5 per cent. in the years 1937-39; finally examination of Table 18 shows that for most of the waters of northern New South Wales the catch of mullet was in excess of 60 per cent. of the total catch, and in those cases where mullet did not figure so largely the total catch was not great. This evidence is taken to be sufficient justification for using the total catch of the State, with data on men, etc. as representing the mullet fishery; this, of course, is for the sole purpose of measuring trends, etc. Whereas the intervention of other species might affect the State total, yet in the case of the Clarence River, where it is known that the catch is predominantly mullet, such effects would not prevail and the data for that locality may be used with greater assurance; and this is true for some other localities. Finally, the mullet proportion is in general so large that variations in the absolute quantity of that species in any year would be immediately apparent whilst variation of any of the many other species would not be so clear. In any case, the general resemblance of these stocks of different species and of the operation of the fishery upon them lends support to the view that the conditions of all would be somewhat similar.

In Fig. 13 the total catch for New South Wales in each year is shown together with the number of men and of boats. The catch line gives a representation of the history of the fishery. Being an inshore one this fishery is dependent upon transport facilities for the despatch of the catch to the market; the rapid development indicated by the steep slope of all lines to about 1915, suggests the extension of the fishery with the provision of transport first by steamers and then by railway (see New South Wales Fisheries Reports, 1888 and other years). After 1915 the catch continues the increase at a very much slower rate, whereas the number of boats continues the same rate of increase; by 1924 the catch has commenced to decrease whereas the men employed increase in number faster than before, while the boats maintain the same rate of increase. The point at 1915 where the parallelism of men, boats, and catch first ceases, seems to be a typical point of inflection marking the inception of an uneconomical phase of fishing. This is shown more clearly in Fig. 14; where instead of number of men and boats the catch per man and per boat is plotted with total catch. This shows how the fluctuations, in the five-year period 1910-1915, of catch per man and per boat are negligible, implying the existence of something of a "steady state", whereas subsequent to that these lines fall away, except for a small and only temporary recovery in 1923. Since the value of boats varies from boat to boat and from year to year, the average value of boats in each year was calculated and then the yield per mean value estimated; the result has been plotted on Fig. 13

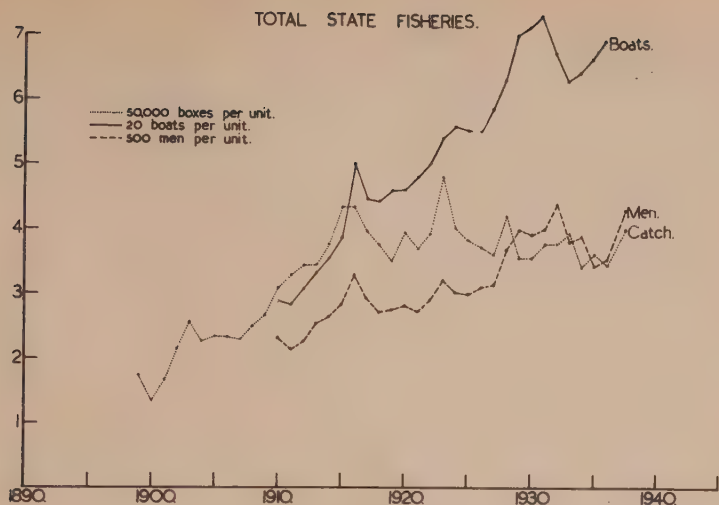


Fig. 13 - New South Wales Fishery. catch of all estuarine species, with number of boats and of men.

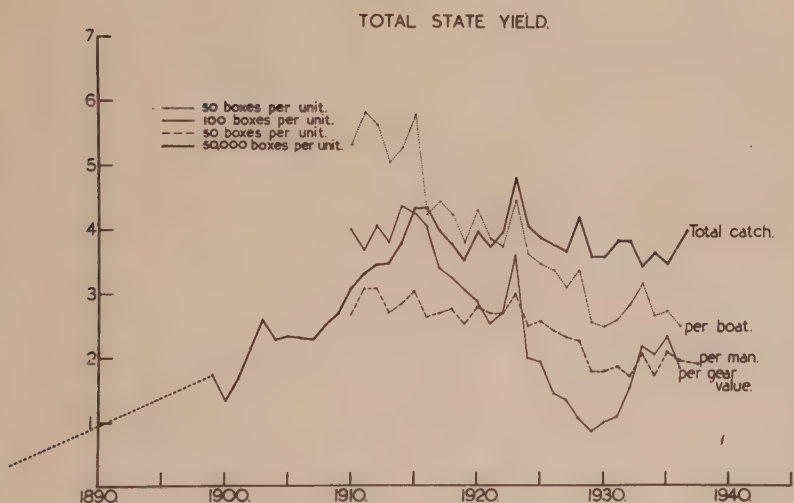


Fig. 14 - New South Wales Fishery: catch of all estuarine species with estimate of yield per man per boat and per average value of boat.

and shows a more emphatic and relatively steady fall from 1915 until 1930, where a recovery was made. That recovery could have been due to the development of the salmon fishery; there is slight indication of recovery in the catch of 1937-38 which could also have been due to the same cause. The Clarence River fishery, which for reasons stated above is assumed to afford slightly better evidence on the pillet fishery, is shown in Figs. 15 and 16. Much the same type of history is shown here: there was rapid development in the early part of the century until 1918, and after that the catch fell away in spite of a considerable increase in gear (after a heavy drop in 1921). The second of these figures shows clearly the decline in catch absolutely and

in proportion to men, boats, and value of boats. This second figure also confirms the idea that a fairly steady state existed near the year 1914; the existence of such stability would indicate a possible optimum fishing intensity and strength of fishing equipment and personnel.

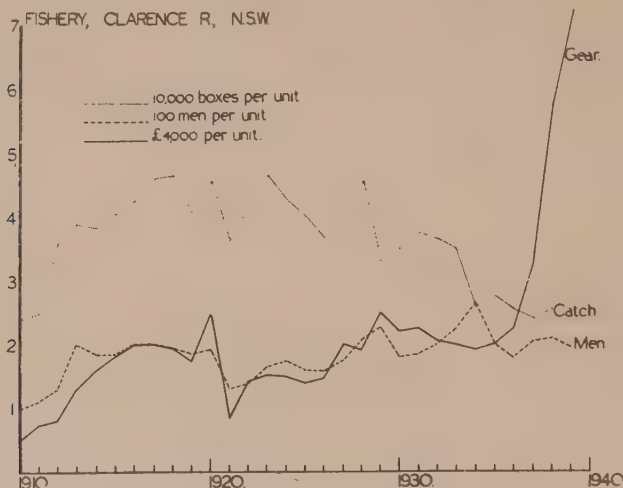


Fig. 15 - Clarence River Fishery: catch of all estuarine species, with number of men and value of gear.

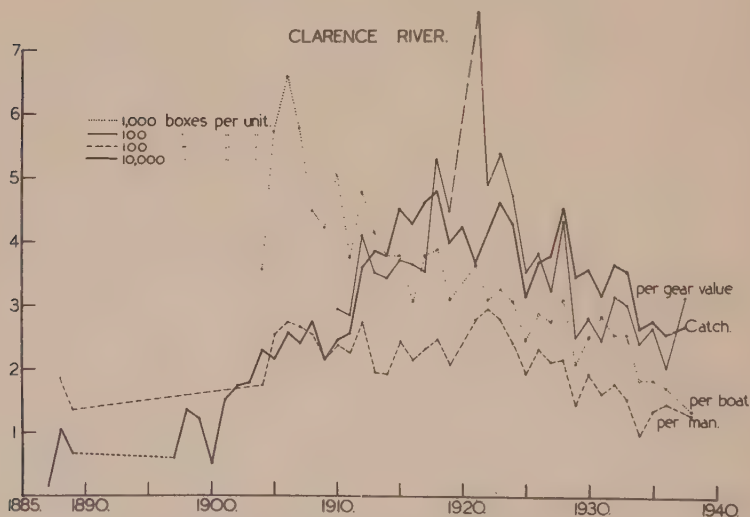


Fig. 16 - Clarence River Fishery: catch of all estuarine species, with estimate of yield per man, per boat and per unit value of boat.

The Annual Reports of the Queensland Department of Harbours and Marine contain, since 1917, a statement of the quantity and value of fish caught in Queensland, together with the number of men and of boats; these data are shown in Figs. 17 and 18 and an estimate of the yield per man and per boat is given in Fig. 19. It will be seen (Fig. 17) that the catch increased to about 1930, after which the trend is, if anything, downwards; the value per ton of the landings changed its trend in 1926, fell until 1934, and

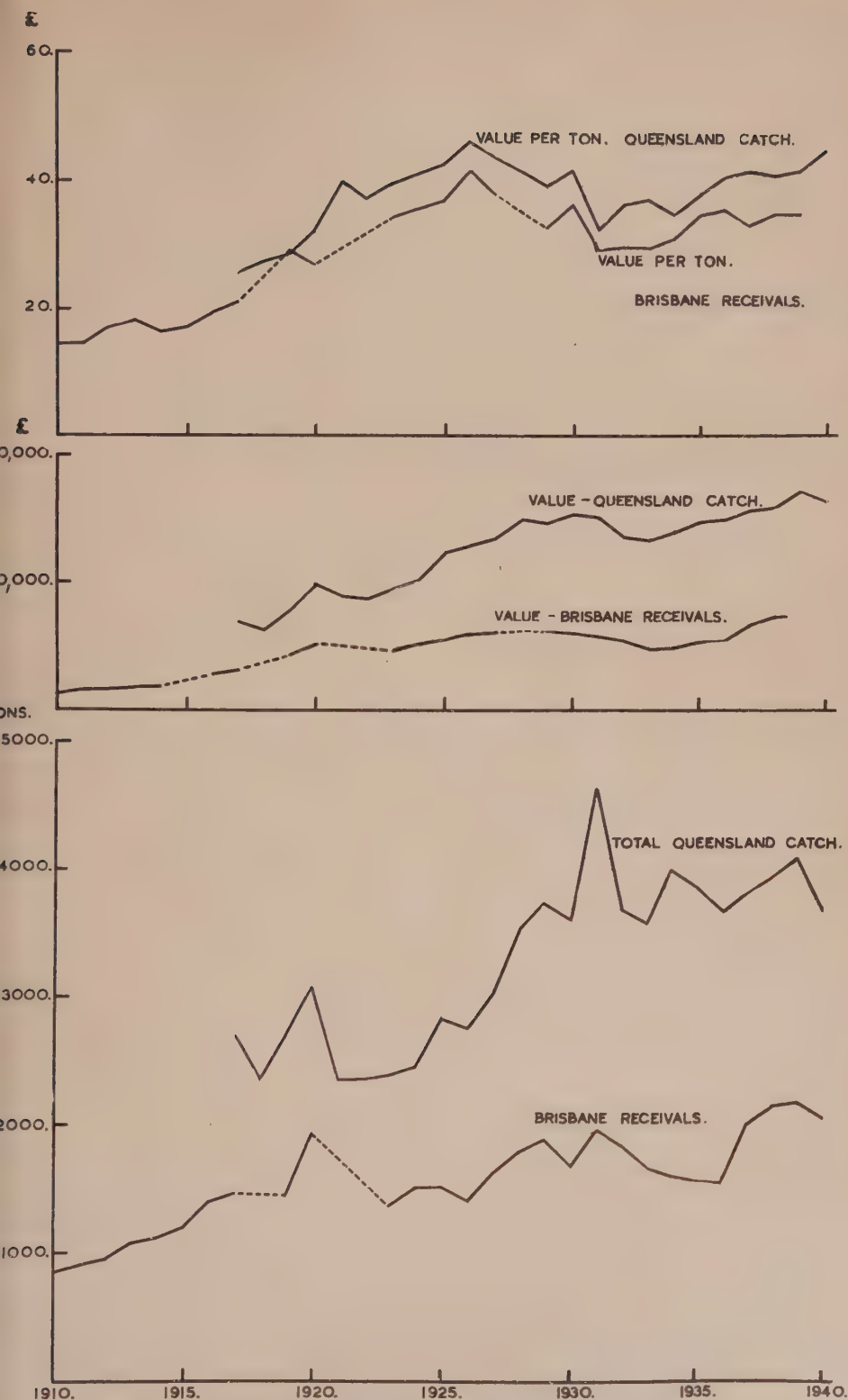


Fig. 17 - Queensland Fishery: catch of all species.

- a. Total Queensland catch and Brisbane receivals,
- b. value of catch,
- c. value per ton of catch.

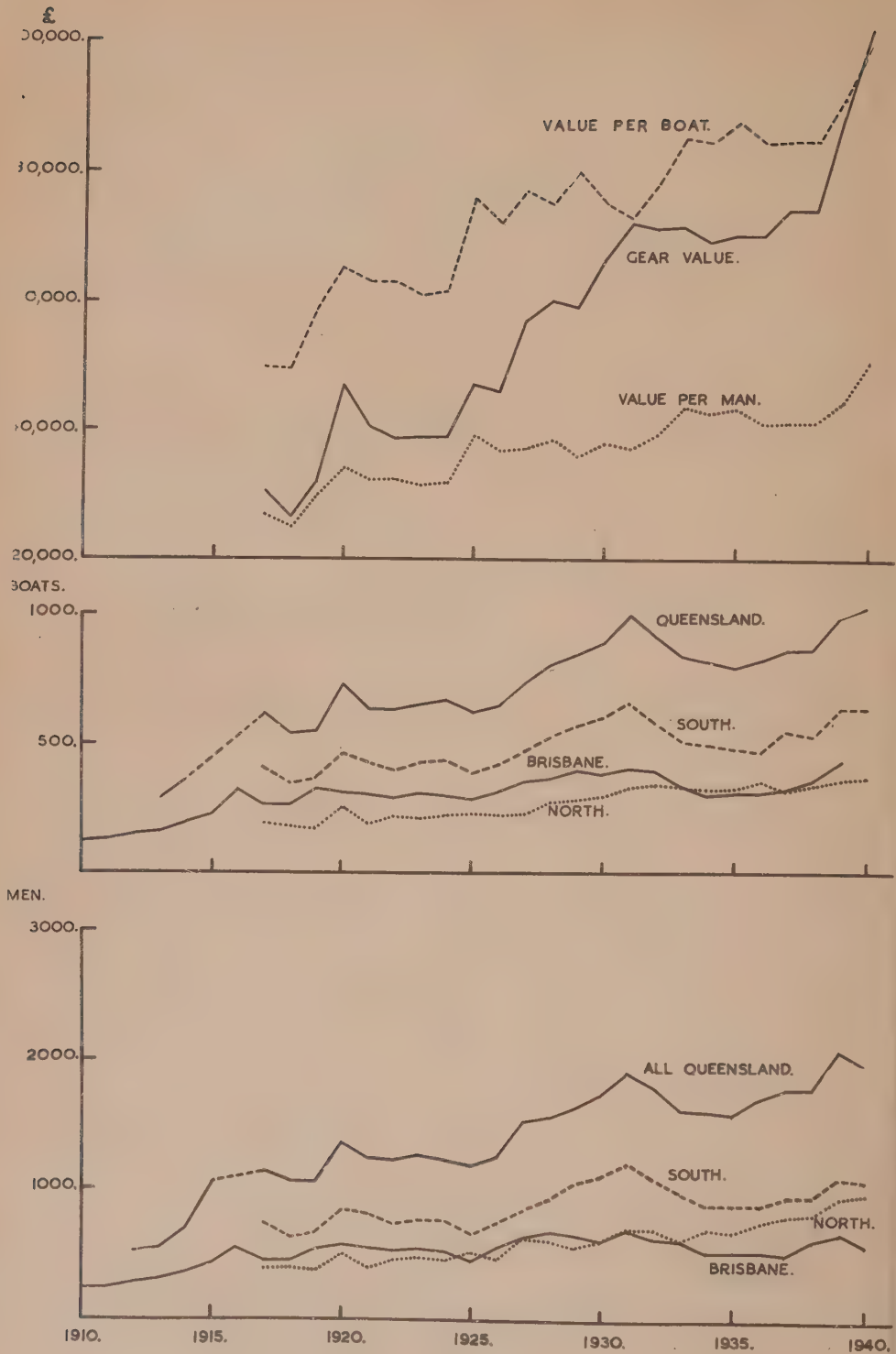


Fig. 18 - Queensland Fishery: men and gear.

- a. Value of gear,
- b. boats,
- c. men engaged.

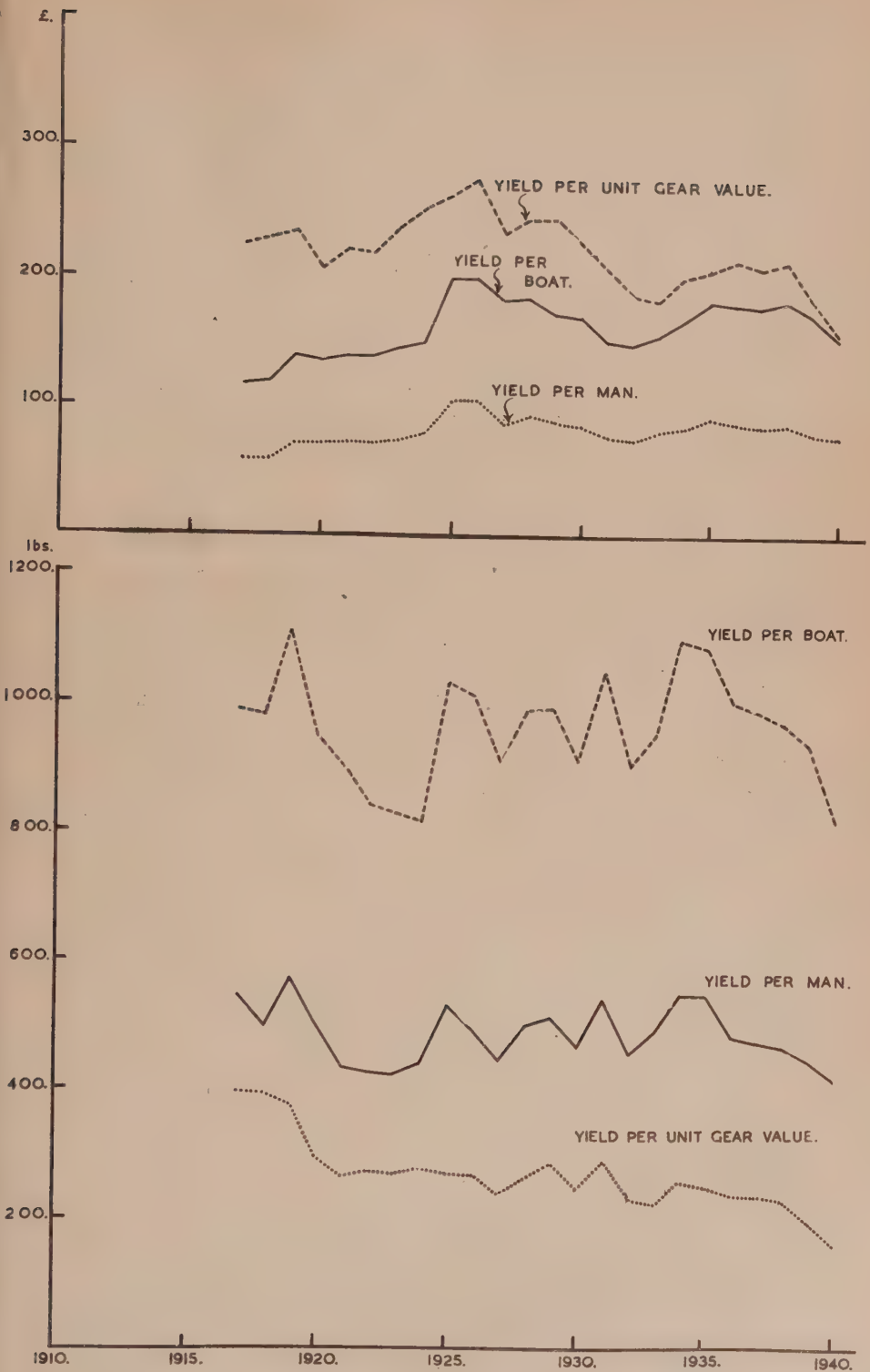


Fig. 19 - Queensland Fishery: Estimates of Yield.

- value of yield per man, per boat and per unit gear value.
- quantity of yield per man, per boat and per unit gear value.

has since recovered somewhat. The numbers of men and of boats (Fig. 18) increased until 1931, and then fell off but recovered in 1939. The value of gear increased until 1931, but then fell off only slightly and in 1936 it began a further increase which has been sustained. The estimates of yield per man, per boat, and per unit of gear value are somewhat inconclusive; in respect of quantity of yield, that for unit gear value alone shows any trend and that is downwards, in respect of value of yield, the trend for boat and man was upwards to 1925, after which it remained fairly stable while the trend for unit gear value has been downwards from about the same point. It would seem that the fishery stabilised in the period 1925-30 somewhat in the fashion of the New South Wales' stabilisation point about 1918, however the position is somewhat obscured by the fact that the Queensland statistics refer to both offshore and inshore fishery, whereas the New South Wales statistics referred only to the onshore fishery. In recent years the Queensland offshore fishery has undergone some development and it is not to be expected that that fishery should yet have reached depletion. The fishery of southern Queensland waters (Bundaberg southwards) is chiefly inshore whilst the offshore fishery operates mainly from ports north of Bundaberg. It will be seen from Fig. 17: (i) that the value per ton of Brisbane receivals is consistently below the value of the whole State catch, (ii) that the value and the quantity of the Brisbane receivals has increased less than the value and quantity of the total State catch; again Fig. 18 shows that the numbers of boats and men at northern ports have consistently increased whilst those for southern ports diminished from 1931 to 1935 and then recovered somewhat. The implication of this evidence relative to the differences between the northern and southern ports is that the fishery of the southern ports, where the mullet catches are made, did reach saturation in 1925-30, but at the time when that happened there began* a further development of the offshore-fishery which successfully concealed the subsequent course of the onshore fishery. This interpretation of the course of events is further substantiated by the data which are available on the mullet catch (Table 18B). This table shows that the mullet catch has been declining in relation to total Queensland catch since at least 1925. As a proportion of the Brisbane receivals it held a fairly steady place until 1934-36, when it fell abruptly - this change however might be due to the change-over in the marketing system, whereby greater quantities of more valuable fish than had been received previously came to the Brisbane Market (see Fig. 17). The decline in the mullet catch is absolute as well as relative; it will be seen in Table 18B and Fig. 12 that the mullet catch increased to a maximum in 1931 and has fallen off since then; also the yield per man† has decreased since at least 1925.

(ii) Fishermen's Reports, etc:

There is evidence from the reports of fishermen that mullet are becoming scarce: schools of fish are not as frequent during the travelling season as they used to be: more time has to be spent looking for them. In so far as this is a crude indication of the amount of scouting time, it is an indication of the relative abundance of fish.

* The Queensland Department of Harbours and Marine Report for 1928-29, gives the first reference to the developing importance of mackerel.

† This calculation is made by dividing the total mullet catch among the fishermen of the southern ports by whom practically the whole of the mullet catch is made.

Fishermen were at one time prepared to refrain from making a capture when the market price was too low; nowadays catches are so infrequent that no opportunity is missed, and the risk of a bad market must be accepted. Reports have been received (see Lindsey *et al.*, 1934) that from some catches made during the travelling season, only the roes have been taken while the flesh has been left upon the beach, but this apparently no longer happens. Also it has been the practice, especially in Queensland, for fishermen to select and leave out of their catches (either on beaches or in shallow water where they could escape) the males, which are smaller and not as highly prized as the females: during the 1940 season it is reported that the catches were so small that the fishermen were not prepared even to do this. This applies to the travelling season when young males often travel in schools with females at least one year older (see p.59) where this secured a release of young age groups the practice is commendable, but in so far as it places a selective mortality upon the females it is dangerous. Possibly the practice might be the explanation of the sex ratio shown in Table 13.

(iii) Biological Evidence:

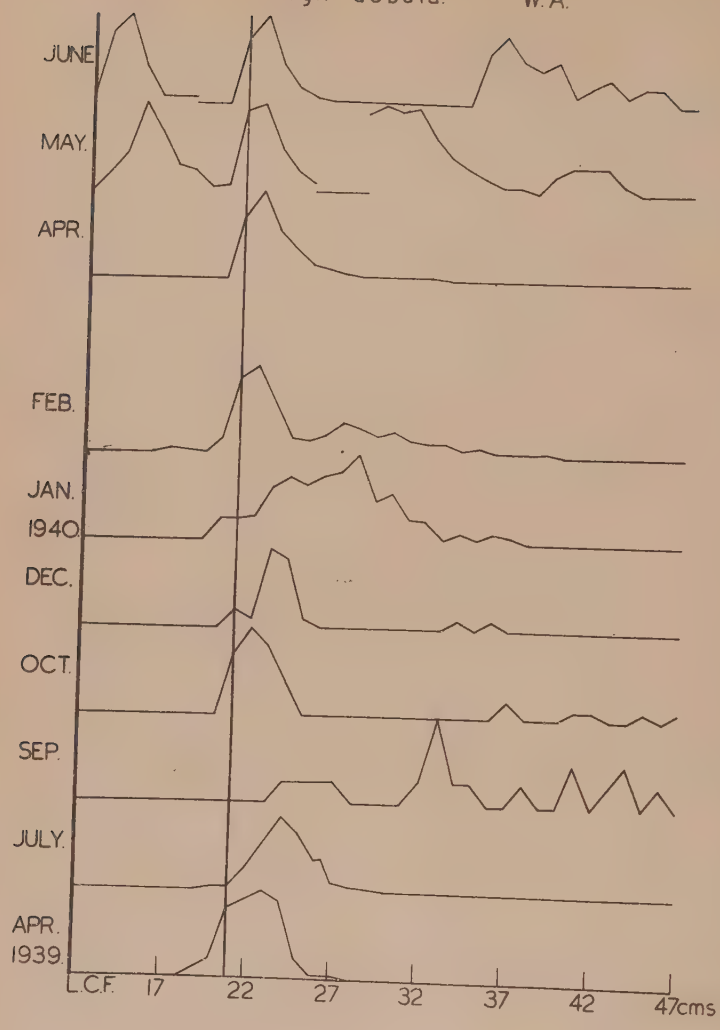
It must be remembered that the data presented here are by no means complete and are not assumed to give a full representation of the composition of the stocks from which they were drawn; that is, no thorough census of the population has yet been possible. On the other hand, since the sampling was fairly random, all age groups within the fishery had about equal chances of occurring in the samples and the picture presented can be accepted as a reasonably approximate one. Such approximation permits an estimate of relative abundance of the year groups and a rough estimate of the average length of the whole catch; it excludes however any estimate of recruitment or mortality rate, and, because of the short time during which data have been collected, it is not possible to say whether the average lengths of the various age groups have changed.

It is felt that the conversion of the length frequency tables into age group tables by means of scale reading, etc. is not warranted until a system of organised market sampling, resembling that described by Hodgson (1929) for herring, is inaugurated. Such conversion, at this stage would give an appearance of precision which would be both false to the data and unnecessary to the preliminary nature of the arguments at this stage.

(a) Western Australian Data:

During 1939-40 some measurements of mullet were made in Perth markets and elsewhere; during 1941 (January to June) a greatly extended series of observations was made. This work is shown in Figs. 20a and 20b. The fish measured in January 1940 were taken in experimental operations in Lake Seppings, and the small fish in May and June were secured in similar operations at Kalgan River and Nannarup. It can be seen that the bulk of the fish which were taken in the markets lie close to the legal minimum of 21 cm., relatively few of the larger fish were measured, in September (1939) May and June (1940), February to April (1941). The larger fish which made up the January (1940) sample were from areas closed to fishing and the sample is, therefore, atypical. In considering the proportion of small fish in the catches, the experimental hauls have

Mugil dobula. W.A.



WESTERN AUSTRALIA. 1941.

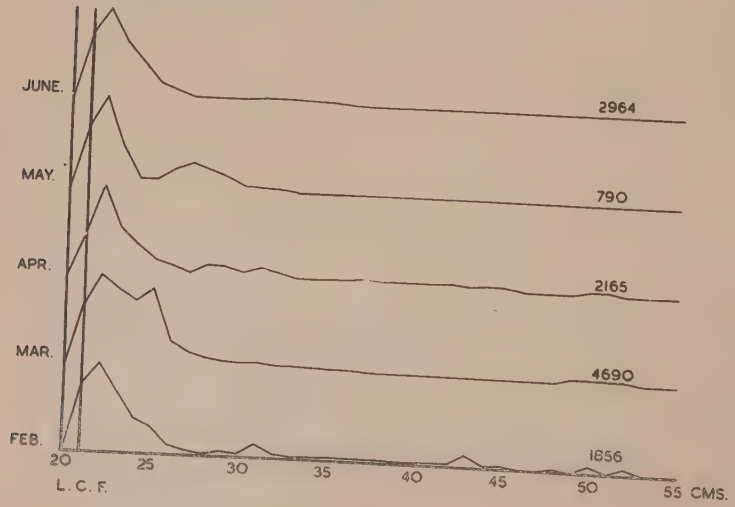


Fig. 20 (a) - Composition of catch, Western Australia (1939-40). The value of the unit for the ordinate varies from month to month to accommodate variation in size of samples; there is also variation in ordinate value between the size-groups as shown by the break in the frequency line. The vertical line at 21 cm. represents the legal minimum.

Fig. 20 (b) - Composition of catch, Western Australia, (1941).

been excluded. The market samples, however, consist in quite large proportion of small fish which are, in point of fact, immature. The proportion of fish over 13 inches in total length (the mean length at first maturity) exceeded 20 per cent. in only one month of 1939/40, and in only two months of 1941. Moreover 11 - 22 per cent. of the 1941 measurements were below the legal minimum of $9\frac{1}{2}$ inches, while 20 - 40 per cent. of the 1939-40 measurements fell below the minimum. As pointed out above, it cannot be held that these measurements reflect accurately the composition of the population from which they were drawn but the percentages cited above appear so consistently and are of such magnitude that they may be taken truly to indicate a serious position. It means that time and energy are spent in catching a proportion of the stocks from which the recruitment for maintenance of supply should be secured; fish moreover which are at a most unprofitable size. The possible condition of the fishery is represented in Fig. 22 which is the familiar mortality curve in which, however, a heavy mortality (80 per cent.) operates after the second year. This diagram is modified from Thompson (1937) and shows as well the effect upon the fishery of changing the fishing rate to 50 per cent. The advantages to be had from such a change in fishing rate, accompanied by an elevation of the minimum legal length, are increased numbers of fish for less effort, and fish of increased weight and increased reproductive ability.

(b) Eastern Coast:

The data for the east coast reveal a somewhat similar story to that for Western Australia. There is the same kind of fishing at and below the legal minimum and the same relative absence of older fish. The situation here is not so serious as it is in Western Australia. Figs. 21(a)-(e) show that for eight or nine months of the year the fishery is operating upon the two and three year old fish and then in three or four months (which may vary) the travelling fish are added to the yield and these are bigger fish, six years old or more, up to 60 cm. in length. It seems quite clear from the 1939 and 1940 data that the fish enter the fishery (lake phase) in July or August (which is, presumably, when they in the lake are safely close to the legal minimum) and remain in the fishery until a year later when they pass out of it temporarily as spent fish. The diagrams show that the older fish are taken mainly in the course of migration, indicating that at the end of that activity they proceed to deeper water, away from nets, and recover. However, since the data is only such as could be accumulated by market and similar measurements we are left in an uncertain position in relation to this portion of the problem. Again the question of fluctuations is a difficult one because, since the fishing is exercised upon so few groups, and at times upon only one group, it is not easy to indicate a preponderant group.

(iv) Discussion of the Question of Depletion:

In the foregoing sections it has been shown that (a) the actual amount of catch of mullet, in Victoria and Queensland, and of all estuarine species in New South Wales shows definite signs of diminution. Reasons are given for supposing that the New South Wales figures on total catch may be considered representative of the mullet stocks. This diminution of catch is not, in New South Wales at least,

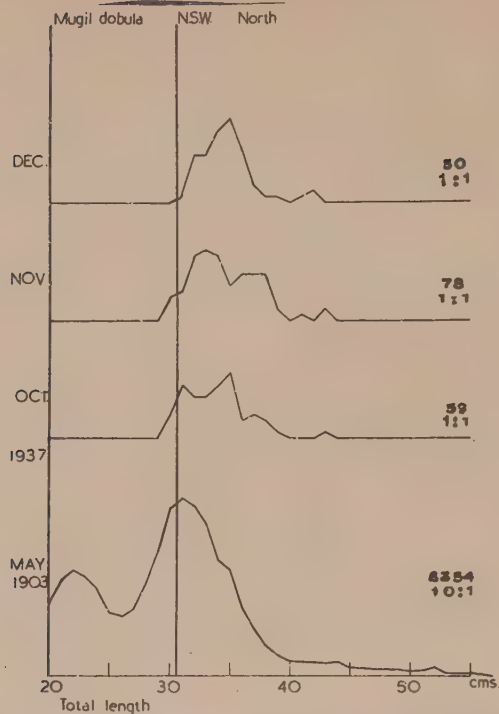


Fig. 21 (a) - Composition of catch, Eastern Australia, 1903-1937. (See Fig. 20(a) in respect of the abscissa and the legal minimum).

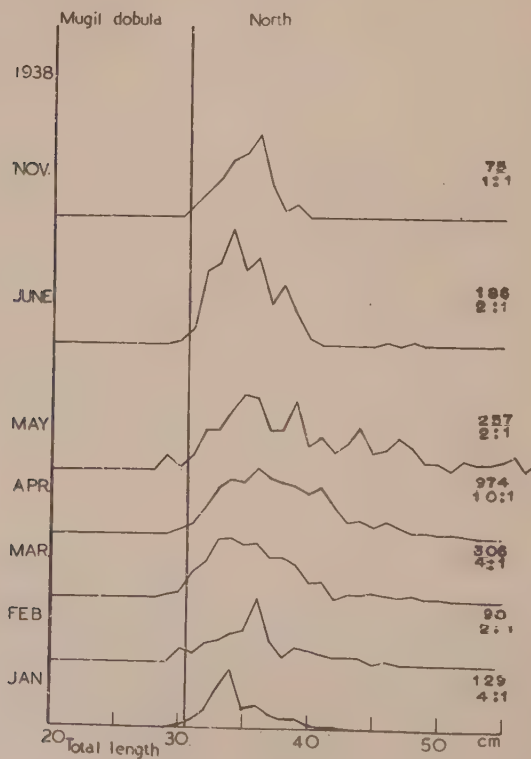


Fig. 21 (b) - Composition of catch, Eastern Australia, 1938.

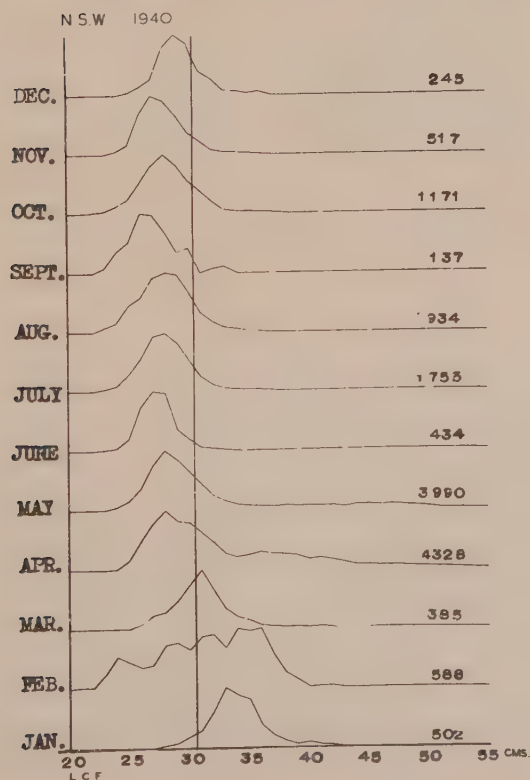
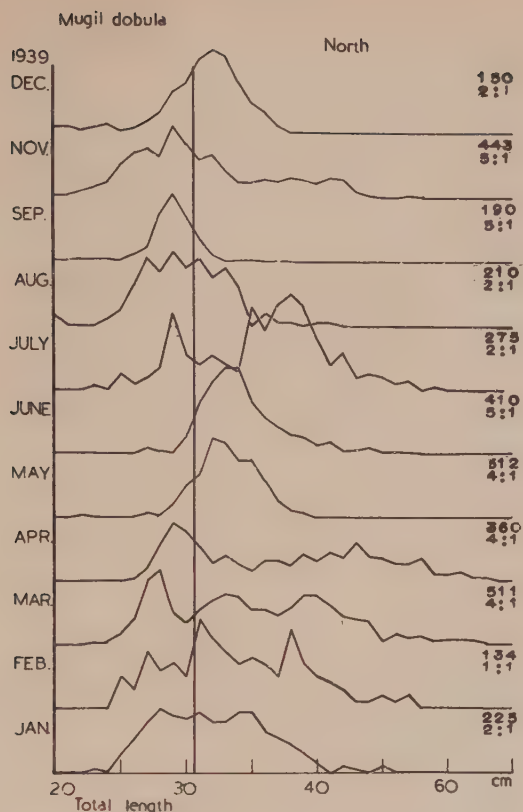


Fig. 21 - Composition of catch, Eastern Australia, (c) 1939, (d) 1940.

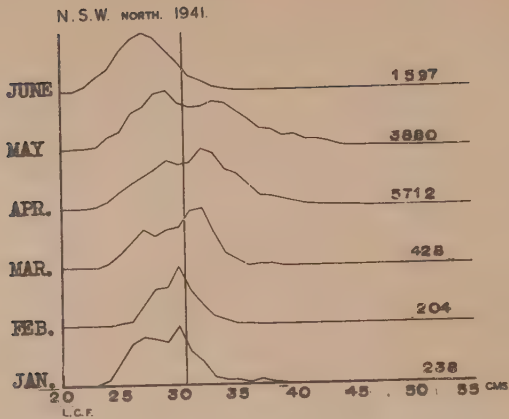


Fig. 21 (e) - Composition of catch, Eastern Australia, 1941.

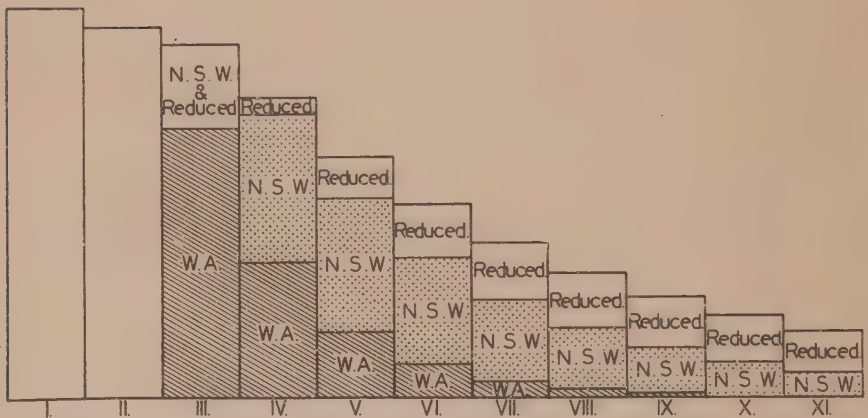


Fig. 22 - Diagram to illustrate mortality among fish stocks subject to a constant natural mortality but differing fishing rates.

accompanied by a reduction in the number of men operating, but rather by a slight increase, and this means (b) that there is a heavy drop in yield per man. In addition there is a quite disproportionate increase in the number and value of boats employed, which has, therefore, meant (c) an even greater decrease in yield per unit of gear. There is evidence that more time is spent in securing an adequate catch, signifying (d) a decrease in yield per unit effort. In respect of biological evidence it is clear first, that (e) a considerable proportion of fish are being caught before they reach maturity, in Western Australia almost 100% of the catch is undersized; and this cannot fail to have very detrimental effects on the stock; it is probable too that (f) both mean length of the total catches and mean length of life are considerably reduced on what they could be. The conclusion from this economic and biological evidence is (g) that the fishing rate, coupled with natural mortality, is quite out of proportion to the recruitment ability of the stocks.

It seems that the array of evidence available, while incomplete, is yet so formidable as to force the conclusion that the stocks are being over-fished. Nevertheless it is possible to deny the conclusion, and the first alternative which has been submitted is that there is an apparent condition of depletion which is actually only the minimum of a natural fluctuation; however, the depleted condition extends over so many years that the fluctuation of which the present years are supposed to be the minimum would be of a period much longer than can reasonably be expected, and therefore, beyond the capacity of the stocks to recover. The mullet of the east coast enter the fishery in the second or third year and remain in it for another three or four years, and it is probable that natural fluctuations could be of the order of from three to six year periods (H. Thompson, 1920); such fluctuations are apparent in the catch statistics. The suggestion that the condition is due to fluctuation therefore is not acceptable (see further discussion p. 85): in any case if it were valid the present fishing rate appears to be such that recuperation would be difficult even if possible, and this is questionable. In the end the effect is the same, the difference being that in one case the whole problem was man-made, in the other the process was begun naturally and human intervention precipitated the ultimate condition.

Again, it is possible to question the data available on composition of catch and to assert that if fuller statistics were available a less pessimistic view would be possible, but as it stands this is no more than wishful thinking for it merely opposes speculation to evidence which actually is available; in any case there is no question of degrees of pessimism: an effort is made here to show that depletion exists and that, therefore, steps should be taken to alleviate the condition.

In considering the cause of the depletion it has been asserted that such depletion as exists is not due to fishing operations; however, in the face of statistical and biological evidence this is surely an untenable position. Moreover no other adequate cause can be nominated. Where the culpability of fishing operations is admitted, fishermen from each of the phases of the fishery deny responsibility. It will be well, therefore, to examine from this point of view the activities of the different phases of the fishery. The inshore fishery, operating chiefly in winter, spring, and summer is indiscriminate as to the groups of fish it takes, but it tends to leave few of the old fish, and it has special access to 0 and I group fish. The beach fishery catches hardgut - II+ and older (but unripe) fish - during summer, and during autumn it catches ripe fish of III group and older.

There is no evidence that the inshore fishery destroys large quantities of 0 and I group fish (except perhaps in Western Australia), although II group fish figure largely in the eastern Australian catches during winter and spring (see p. 79 and Table 5). In so far as this fishery catches immature stock, restrictions should be placed on the size of its gear as well as on the place and time of use of the gear in certain prominent cases.

The beach fishing for hardgut fish does not capture only immature (virgin) fish but the proportion that virgin fish form of the captures here is so great that such captures should be entirely prevented. The beach fishing during the travelling season is working on the best classes of fish when, however, they seem to be most accessible; on the other hand,

the hazards of beach fishing would appear to allow quite a large escape margin.

The culpability of any phase of a fishery (in respect of depletion) depends upon the extent to which the fishing intensity in that phase is at a higher level than is permissible by the fish stocks, and also upon the extent to which that phase is responsible for the destruction of small fish (thereby reducing recruitment). It will not be possible to give accurate estimates of the existing or of appropriate fishing intensity in the two phases until a greater body of data is available. In respect of its captures of immature fish (as hardgut) the beach fishery is extremely culpable and should be restrained. In so far as its efforts are indiscriminate, the inshore fishery destroys much immature stock in both western and eastern Australia, and this fishery also should be restrained.

A point provoking a great deal of controversy is the question of the protection of roed fish. Considerable weight is often attached to the suggestion that because the fish in the travelling schools are full-roed and about to spawn they should not be caught. However, there does not seem to be any reason why a full-roed fish should be entitled to any greater protection than any other mature fish. Unless the fishery upon full-roed fish disturbed them in the act of spawning no especial blame should attach to that fishery. At this stage the main point is to secure a sufficient bulk of spawning and the first move towards securing that should be by ensuring that all fish have the chance of spawning once.

5. SUGGESTIONS FOR CONTROL.

Before proceeding to the suggested programme of control, it is necessary to set out the case for the restrictions which are to be suggested and to indicate why the case cannot be met by present methods of control.

(i) Case for Restriction of Fishing:

Evidence is presented in previous sections of the existence of a condition of depletion in the estuarine fisheries under consideration. This depletion can be considered from two aspects, of which the first is biological and the second economic.

(a) Biological Consideration:

The question of animal numbers and the causes of their fluctuations has been examined by a number of workers (see Elton, 1927; Nicholson, 1933; Thomson, 1939), and the subject has been made an object of fisheries research by Hjort (1914), Baranov (1925), Volterra (1928), Meek (1930), Russell (1931), Hjort, Jahn, and Ottestad (1933), Thompson and Bell (1934), Graham (1935a, 1935b, 1938), Thompson (1937), and see also Conseil Permanent International pour l'Exploration de la Mer (1939). In Graham (1938) the natural increase of a stock is very simply represented by V (rate of natural increase) = $A + G - M$, where A = growth in weight by reproduction, G = growth in weight of individuals, and M = natural mortality. According to Graham this expression

"is the 'interest' of the stock, and if fishing removes no more nor less than this, the stock will be unchanged in weight". And although under some circumstances it is possible to fish at an even greater rate (so that in effect the fishing is producing a reduction in principal) without great detriment to the fishery, such cases are not common and in most cases the reduction in principal causes such reduction in interest that it is unable to maintain the stock at its previous level. With a fall in principal, therefore, there follows a diminution of interest and the process continues and can accelerate.

On the other hand, natural populations frequently exceed the optimum density for the area which they occupy (e.g. during plagues). Such excesses may be detrimental to the existing stocks or to subsequent generations either because of competition for food or of consequent increases in predators or other enemies. In any case it is easy to conceive that in so far as fishing may prevent such excesses its presence may be beneficial. The concept of optimum population density has, therefore, developed along with the concept of optimum fishing rate: these optima are, however, based upon biological data in respect of natural increase, natural mortality, and the capacity of the habitat to support stocks of the species in question.

Again, considerable attention has been paid to the question of fluctuations in animal numbers. Such fluctuations are due to interaction of the capacity of the species to increase in numbers and the opposition to such increase offered by the limits of the habitat and by the activity of natural factors responsible for natural mortality. It is to be assumed that fluctuations consist simply of alternating periods of greater and lesser than average numbers. There seems no reason to assume that such fluctuations should be regularly periodic since, as for example in fish, greater numbers could be due to successful spawning, survival of larvae, or both, and smaller numbers could be due to the converse; success would depend partly upon the fish, partly on sea conditions and partly on availability of food; clearly in the absence of evidence it may be assumed that the happy congruence of involved factors should be quite irregular. Moreover, a maximum could be due to a series of years, or to only one year, of such favourable circumstances and in the former case would last longer than the latter; the converse would be true of minima. It is possible, but unlikely, that where a fish (as in the present case) takes three years to mature the successful spawning of one preponderant year group should be effective in prolonging the maximum which that year group was providing; in fact to assume so is in effect to smooth out fluctuations and substitute an escalated effect. Therefore maxima (and minima) should tend to be independent, and fluctuations may be expected to have a period no less than the time to first spawning and no greater than the time in which any group can influence the yield; that is, in the present case from 3 - 6 years. Further irregularity would be provided by any prolonged maximum or minimum.

To sum up: optimum fishing rate should be established upon biological knowledge of the fish population, involving, essentially, knowledge of the optimum density of population, and recognising quite clearly the nature and extent of natural fluctuations.

It is possible, however, to indicate that when depletion is demonstrated it is probable that by adopting

an optimum fishing rate (accurately assessed) not only will the yield per unit effort (as a basis of estimate) be restored to a previous level, but it may be placed in excess of that. This follows simply from a demonstration that actually, by fishing, it is possible to establish a higher level of principal and recruitment from which to remove the yield. Thompson and Bell (1934), Graham (1938, 1939) and Russell (1939) have shown that a reduction in fishing rate can by allowing greater natural increase and establishing greater principal, actually secure a greater yield per unit than a higher fishing rate. Natural mortality is much the same as fishing rate in being a process of removing fish from the stock; therefore, to add fishing rate to natural mortality is to increase the removal rate and should, it would seem, result eventually in a reduced yield per unit. However, natural mortality is effective upon all age groups and is most intense upon the younger fish. Such greater mortality among juveniles may in part be due to food competition. Most fishing is allowed on only older groups and often only on mature stock: if there is competition by older fish for food required by young fish the removal of the former should allow the latter to grow. The advantage in catching the older fish and allowing the younger fish to grow can easily be demonstrated. On the other hand competition for food is one only of a number of factors known to operate in an intensity varying directly with the stock available for such operation; fishing, therefore, reduces (by anticipating) the rate of natural mortality. The total effect should be to reduce the mass of the older groups and to clear the ground somewhat for the more rapidly growing younger groups and to obtain more rapid turn-over.

(b) Economic Aspects:

Figs. 13-19 show quite clearly that not only has there been a falling off in yield per man, per boat, and per unit of capital involved, but there was actually a greater quantity of fish caught in 1915 than in 1936, and in the latter year there were more men and a greater number and value of boats, thus:

	<u>Men</u>	<u>No.</u>	<u>Boats</u> <u>Total Value</u>	<u>Mean</u> <u>Value</u>	<u>Catch</u> <u>(boxes)</u>
1915	1,433	799	£39,565	£51	217,897
1936	1,775	1,388	£133,154	£96	174,403

	<u>boxes</u> <u>per man</u>	<u>YIELD</u> <u>per boat</u>	<u>per unit</u> <u>boat value</u>
1915	152	280	428
1936	98	125	182

The obvious conclusion from this is that all the fish that should be taken from these stocks could well be taken by fewer men and boats. The change in cost of boats may mean such a change in efficiency of those boats that the number of men required by this fishery is still less.

A further aspect of this situation is the average return to the fishermen from their activities. It will be seen from Figs. 14, 16, and 19 that upon estimates of value of production, each fisherman's activities yield less than £100 of primary produce per year; but the actual return to

the fishermen is considerably less since marketing costs (of 10-20 per cent.) are deducted before the fisherman is paid. This leaves the conclusion that this fishery is considerably impoverished.

On the other hand it would be an extreme foolishness to use this impoverished condition as an argument for refraining from action. The situation is that more operatives are endeavouring to draw a living from this fishery than the value of even its highest possible yield could support; the presence of such excessive activity further aggravates the position and produces depletion so that the yield is considerably diminished. Unless action is taken the situation must become worse. The only rational action is deliberate limitation of the catch to proportions (and composition) demonstrated biologically as being able to maintain the stock at its level of greatest growth and reproduction. Although such limitation may temporarily impose hardship upon some operatives, that hardship will be small compared with the permanent losses if no limitation is made. On the other hand successfully imposed limitations should produce beneficial effects within relatively few years.

(ii) Inadequacy of Existing Control:

In the preceding section it is shown that need exists for restriction in fishing and that benefit can accrue from such restriction. The task of restriction is to compel the capture of fewer fish and to reduce the number of men and of boats, the amount of time and labour spent and the ground covered.

Temporary reduction of catch can be achieved, in part, by raising the minimum legal length. This also provides a necessary precaution to ensure adequate recruitment.

Existing restrictions are reviewed in Section 1(v). It is shown there that such control is not organised to prevent the effect of any restriction being nullified by absence of restriction in some other place or at some other time. For instance, in only few cases (of which the Noosa River is one) is it known that an existing restriction is truly effective in preventing the capture of fish observed. In most cases a catch missed in one situation may be secured in another by a different, if not by the same, crew. The point is that whatever restrictions are imposed at present in any set of areas are off-set in adjacent areas by increased effort there. Closure of one beach is useless if the fish which pass over it can all be caught at the next. Also closures of narrow entrances to lakes, etc. are ineffective against intensive fishing inside the lake and on the outside ocean beaches. It is obvious that a direct approach must be made to the problem and a strong effort made definitely to limit the catch. This is no more than has been done in many other fisheries and is no less than can be conceded to the future of this fishery. An allowable catch must be decided upon empirically from examination of the fishery and its history; this allowable catch limit must immediately be enforced by administrative measures, but must early be converted into a biologically founded "optimum catch", and thereafter modified according to expectations of fluctuations of stock or to signs of definite change.

The problem is not nearly so much one of preventing the capture or destruction of very juvenile fish as of restricting

the fishing upon the older fish. Mullet are very active fish and the juveniles escape the large nets which are used in the waters where they are found. So far it has been a problem in this research to secure samples of the first and second year fish. It is true that many three year old (but immature) fish find their way to the market, but, as has been indicated above (p. 77) the legal minima of some States allow the capture and sale of those fish.

As the system of control stands at present it burdens administration with a tremendous task of justifying and maintaining a complex system of closures and of restrictions upon gear, whilst leaving it open to fishermen to secure, by increased effort and improved gear, catches which in fact have been quite effective in exhausting the possibilities of the stocks.

(iii) The Basis for Determination of Restrictions:

The purpose of restrictions is to ensure that fishing operations should hold an appropriate relationship to the fish stocks so that the catch is of such size and composition that the recuperative powers of the residual stocks are not impaired. In this respect there are two immediate objectives:-

1. Protection of special groups
2. Limitation of catch to allowable quantity.

These objectives may be approached by the following restrictions:-

- A. Upon Gear:
 1. Size - net length and depth, net proportions (bunt, wings, etc.). Mesh sizes.
 2. Use - times, places
 3. Quantity - number of boats, etc.
- B. Upon Catch:
 1. Groups - legal minima.
 2. Quantity - of all groups by quotas.

That resource should be had to all of these (except the last) at the one time is recognised by Government Departments, as will be seen by referring to the account of existing control in Section 2(v). A decision has to be made, however, on the severity of the restrictions to be imposed, and also on which restrictions are to be employed.

Restrictions as to gear size should, in the first place, support protective measures taken by way of legal minima, and in the second place should themselves impose limits on fishing intensity. In respect of their support to legal minima the specified allowable nets should be of such design that only fish of legal size and upwards can be taken; at present there is, in this connection, variation in the specification of allowable nets and there is considerable difference of opinion on what specification is best for the fish of various sizes. In respect of the role of legal minima in imposing limits on fishing intensity, the question is a complex one involving; (1) the area of fishing grounds, (2) the density of fish populations in those grounds, (3) the number of fishermen on those grounds, and (4) the efficiency of nets of various sizes. It is a matter which would, in a scientifically controlled fishery, require to be extensively investigated.

Restrictions on time and place of use of gear should also consolidate the protection of special groups and assist in controlling fishing intensity, but on the other hand, for the sake of simplicity in supervision and of convenience of the fishermen, these restrictions should be imposed only where it is shown that the special groups are, at the times and places selected for closure, especially liable to destruction, or alternatively, where the restrictions on gear size (coupled with legal minima) cannot be expected to be sufficiently effective in reducing fishing intensity. It is usual to use closures for the protection of spawning grounds at spawning time in order that the spawning act should not be interrupted, but from the complete impossibility so far to secure even a pair of spawning mullet it may be inferred that such closures are not warranted in this fishery. Closures are used also for the protection of nursery grounds where the allowable nets would capture immature fish or the fishing operations would be detrimental to the fish; however no clearly defined nursery areas have yet been shown for mullet and the nets should not be able to capture immature fish. Finally, an effort is made to protect schooled fish when moving out through an estuary (on this point see p. 84).

Exclusion of all or the majority of immature fish from the catch by means of legal minima has a great deal to recommend it as a direct and effective measure which can be implemented with some ease and some speed. The exclusion of these groups should ensure: (1) replenishment by spawning, (2) abundant recruitment for the fishable stocks, (3) reduction of fishing intensity, and (4) that the catch should be composed of fish of good marketable size. Moreover, it should effect the restraint upon both inshore and beach fishing which was indicated on p. 85 as being necessary.

Finally the direct limitation of catch by means of a quota system would naturally be the most efficient method of controlling fishing intensity, but it would be employed only when other restrictions had been tried and found inadequate.

(iv) Proposed System of Control, etc.:

Firstly legal minimum lengths should be adjusted to make them compatible with biological facts. Evidence is presented in Section 3(vi) that this species of mullet matures at the end of its third year when this group has a mean size of about 33 cm., with a range from 30 cm. to 36 cm. In the present condition of the fishery it is advisable that practically the whole of this group should be immune from fishing activity until it spawns. Reference to Fig. 6 will show that during this third year the fish grow from a mean length of 26 cm. to a mean length of 33 cm. about which mean there is a scatter to 3 cm. on each side. It is clear that a minimum shifting from 29 cm. to 36 cm. during each year could be sure of protecting all these fish and allowing full pressure on already spawned fish, but the sudden changeover indicated by the diagram might defeat the purpose of the measure; a more effective and more practical method would be that of a double minimum such as at present in force in Queensland. The lower minimum, to operate all the year in the lake fishery, should be 32 cm.; the upper minimum for all beach fishery, should be 35 cm. However, the migrating fish, in schools, are liable to be subject to fishing before they get away to the sea and the upper limit should, therefore, be in force in the estuaries, lakes, etc. during the travelling season. The travelling season occupies approximately three

months (vide Fig. 10) for each major area, and extends, on the eastern coast from about February to about June. The existing and possible legal minima are shown in Fig. 23.

LENGTH

cms.

60

50

40

30

20

10

MAY.

MAY.

MAY.

MAY.

Fig. 23 - Scheme to show the existing legal minimum for New South Wales and possible alternative systems in relation to the growth of successive age groups. The dotted line is the existing legal minimum in New South Wales. The curved broken line is a shifting minimum lying at 3 cm. (= 1-1/5 inches) above the mean length of the group which should be protected (III+ group). The continuous rectangular line represents a biphasic system such as that in use in Queensland but lying at 35 cm. (= 14 inches) for the travelling season and 33 cm. (= 13 inches) for the non-travelling season.

Although there is some difference in length between the males and females, the males already outnumber the females and any effort to place the minimum at a lower level because of the males would simply increase the number of males in the catch with a disproportionate (smaller) increase in the number of females. As stated above (Section 3, (viii)), the river and lake fishery operates chiefly upon the three-year old and immature four-year old fish, since the older fish retreat to deeper waters, therefore, efficient protection of the three-year old stock would mean for a while at least, a considerable reduction of the catch by this fishery. This problem shows the need for more direct approach to the question of control. Finally, the difference in time of travelling between widely separated areas (e.g. north-east Victoria and Hervey Bay, Queensland) might make it advisable to have the higher legal minimum operative in periods advancing in time with the movement of the travelling schools.

Secondly, this system of legal minima should be supported by appropriate restrictions upon gear; that is, the allowable mesh sizes and net length should be such as to permit the escape of all undersized stock.

Thirdly, this system of protection should be supported by the three following programmes:

- I. A system of statistics should be established. It requires primarily the establishment of trade categories so that returns may be made of the weight of fish of each trade category caught in each locality in each return-period. Biologically derived constants would enable the conversion of such data into number of fish of each age, and the bulk of such data would lend assurance in the interpretation of fluctuations. Further statistics on number of men and of their nets and boats are essential. The system should be continuous to permit rapid adjustment of quotas.
- II. A programme of technical research upon the economics of the industry in general and of the fishermen, and upon the efficiency of nets of different types and sizes should be embarked upon.
- III. An extension to biological research is required, including continuous market measurements and age analysis of the catch, further work upon spawning, and tagging operations to secure estimates of fishing rates, natural mortalities, recruitment, and actual population densities.

Fourthly, some reduction in the personnel and equipment of the fishery should be recommended to the operatives themselves. In Section 4 (i)c, evidence is presented that the optimum level of catch and fishing intensity (as represented by men and gear) possibly existed in the 1913-15 period, and a return to those levels would be advisable. This question is discussed in Section 5 (i)b.

Fifthly, should the measures above prove inadequate, a system of direct limitation of catch by quotas should be instituted.

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TABLE 1A - ALLOWABLE NETS.

Seine (haul) Nets.

Locality	Purpose and/or Species	Length - not to exceed		Mesh		
		Total	Bunt	All	Not less than - Bunt	Wings
		Fathoms		Inches		
<u>West. Australia:</u>						
Swan River	-	100	-	2 $\frac{1}{4}$	-	
" "	-	30	-	2 $\frac{1}{2}$	-	
Leschenault Est.	-	100	-	2 $\frac{1}{4}$	-	
Peel Inlet	31 Mch.-31 Oct. Garfish	150	$\frac{1}{3}$ Total	-	1 $\frac{1}{8}$	2
" "	31 Mch.-31 Oct. Whiting	150	$\frac{1}{3}$	-	1 $\frac{3}{4}$	2 $\frac{1}{4}$
" "	All marine Fish	200	-	2 $\frac{1}{4}$	-	-
<u>Sth. Australia:</u>						
	-	120	$\frac{1}{3}$ - $\frac{1}{2}$ Total	-	1 $\frac{1}{4}$ (30' deep)	1 $\frac{7}{8}$ (15' deep)
Any net with mesh 2 $\frac{1}{2}$ " is not subject to these restrictions.						
Marino to Outer Harbour	-	200	-	1 $\frac{7}{8}$	-	-
Murray Lakes and the Coorong	-	10	-	5	-	-
	but for Mullet =	6	-	2 $\frac{1}{4}$	-	-
<u>Tasmania:</u>						
	Mullet Net	-	-	2	-	-
	Seine	-	$\frac{1}{3}$	-	1 $\frac{1}{4}$	2
George's Bay		20	-	-	-	-
<u>Victoria:</u>						
Port Phillip	-	200	-	-	-	-
Western Port	-	-	-	1 $\frac{1}{4}$ -1 $\frac{1}{2}$	-	-
Gippsland Lakes	-	200 for pie- balling				
		400	-	-	-	-
Lake Tyers	-	180	-	-	-	-
Mallacoota	-	400	-	-	-	-
Tamboon	-	400	-	-	-	-
<u>N. S. W.</u>						
(a) Various waters	General	400	50 or $\frac{1}{3}$	-	2	3
(b) Various waters	"	250	50 or $\frac{1}{3}$	-	2	3
(c) Manning River	"	300	50 or $\frac{1}{3}$	-	2	3
(d) Lake Macquarie	"	550	⁵⁶ (21+14+21)		(2+1 $\frac{1}{8}$ +2)	3
(e) Camden Haven	"	200		3 $\frac{1}{2}$		
(f) St. George's Basin	"	550	100 or $\frac{1}{3}$		2	3
(g) Wallaga Lake	"	200		3 $\frac{1}{4}$		
(h) Tuggeran Lakes	" (i)	550	50 or $\frac{1}{3}$ (12 $\frac{1}{2}$ +25+12 $\frac{1}{2}$)		(2+(1 $\frac{1}{8}$ or 2)+2)	3
(i)	(ii)	720	50 or $\frac{1}{3}$ (12 $\frac{1}{2}$ +25+12 $\frac{1}{2}$)		(2+(1 $\frac{1}{8}$ or 2)+2)	3
(j) Durras	"	200		3 $\frac{1}{4}$		
(k) All other tidal waters	"	200	50		2	3
(l)	Salmon	200		2 $\frac{1}{4}$		

(Contd.)

TABLE 1A - ALLOWABLE NETS. (Contd)

Seine (haul) Nets.

Locality	Purpose and/or Species	Length - not to exceed		Mesh Not less than -			
		Total	Bunt	All	Bunt	Wings	
<u>N.S.W. (Contd)</u>		Fathoms		Inches			
(m)	Garfish	150		1 $\frac{1}{8}$			
	bull-ringing(i)						
(n)	" (ii)	150	$\frac{1}{3}$		1	2	
(c) Tuggerah Lakes	" (iii)	400	(38+24+38)		(2 $\frac{1}{4}$ +1 $\frac{1}{8}$) + 1 $\frac{1}{8}$ +(2 $\frac{1}{4}$ +1 $\frac{1}{8}$)		
(p) Clarence River	Whiting (i)	150		2 $\frac{1}{4}$			
(q) Port Stephens	" (ii)	150	$\frac{1}{3}$		1 $\frac{1}{4}$	2	
<u>Queensland:</u>							
Pt. Wange-Dble Is.							
Point	(a)	-	200	$\frac{1}{3}$	-	2 $\frac{3}{4}$	3
	(b)	Ringling	225	-	-	3(in $\frac{1}{3}$)	3 $\frac{1}{2}$
Noosa Lakes	(c)	-	400	-	-	2 $\frac{3}{4}$ (in $\frac{1}{3}$)	3
Dble Isl. Pt. and							
Normanton	(d)	-	200	$\frac{1}{3}$	-	3	3 $\frac{1}{2}$
	(e)	Whiting	125	-	2	-	-
	(f)	Garfish	60	16	-	1 $\frac{3}{8}$	2

TABLE 1B - ALLOWABLE NETS.

Mesh Nets.

Locality	Purpose and/or Species	Length - Not more than	Mesh - Not less than	Allowed Use
<u>West. Australia:</u>		Fathoms	Inches	
Peel Inlet	All marine Fish	250	2 $\frac{1}{2}$	
<u>Sth. Australia:</u>				
Marino to Outer Harbour	-	200	1 $\frac{7}{8}$	-
<u>Tasmania:</u>				
Derwent River	-	-	3	-
Huon River	-	5	2 $\frac{1}{2}$	Sunrise to sunset
George's Bay	-	20	4	Sunrise to sunset Sep. 1 to Apl. 30 6 such nets 20 fathoms apart
<u>Victoria:</u>				
Port Phillip	-	--	4	Apl. 1 to Oct. 30
Western Port	-	600	1 $\frac{3}{4}$	Midnight Sunday to noon Saturday
Port Albert - Cowes Inlet	-	700 (for two or 900)		
Gippsland Lakes	-	1200	4 $\frac{1}{2}$	
		700	4 $\frac{1}{2}$	
Lake Tyers		600		
<u>N.S.W.</u>				
(a) Hawkesbury R.	General	200	3	
(b) Port Jackson	"	125	3	
(c) Durras Water	"	200	3 $\frac{1}{4}$	
(d) Wallaga Lake		200	3 $\frac{1}{4}$	
(e) All other tidal waters		400	3	
(f) Tuggerah Lakes	Flathead	400	2 $\frac{3}{4}$	as sunk net only

TABLE 2A.

Sample List - 1903.

Number of Hauls	Date 1903	Locality	Number of Mullet Caught
1, 2, 3.	20th Apl.	Brays Bay, Parramatta River	339
4	23rd "	Pt. Hacking, Yenabilli Flat	0
5	23rd "	do Outside the Spit	0
6	24th "	do Fisherman's Bay	3
7	24th "	do O.L. No.2,723 (Channel)	54
8	27th "	do Yenabilli Flat	53
9	28th "	do West side of the Spit	116
10	1st May	Pt. Hacking, Channel to Fisherman's Bay	36
11	1st "	Pt. Hacking, Fisherman's Bay	0
12	8th "	Lake Macquarie, Black Ned's Bay off the Lake Channel	85) 21)
13	8th "	ditto ditto	109
14	9th "	Lake Macquarie Channel, Grays Pt.	194) 75)
15	11th "	Lake Macquarie, Black Ned's Bay, East Side	387
16	11th "	Lake Macquarie, ditto Nth.Side	851) 223)
17	11th "	Lake Macquarie, north-west corner	143) 606)
18	12th "	Lake Macquarie Channel, mouth of entrance to Black Ned's Bay	102
19	13th "	Lake Macquarie, Black Ned's Bay	62
20	13th "	ditto north side	268
21	13th "	Lake Macquarie Channel, mud flat below the bridge	454
22	27th "	Pt. Hacking, Nth.side of mud flat at Deer Park	3
23	27th "	Pt. Hacking, Sth.bank of channel above Deer Park	5
24	27th "	Pt. Hacking, north bank of channel above the Deer Park	24
25	27th "	Pt. Hacking, north-west arm	4
26	28th "	Pt. Hacking, inside the Spit	12
27	28th "	Pt. Hacking, Yenabilli Bay	80) 5) 110)
28	28th "	Pt. Hacking, (No. 2)	18) 20)
29	29th "	Pt. Hacking, Ballast Heap	505
30	23rd June	Pt. Hacking, Yenabilli Flat	34
31	24th "	Pt. Hacking, Outside the Spit	48
32	25th "	Pt. Hacking, Channel above Ballast Heap	42
33	26th "	Pt. Hacking, Yenabilli Bay No. 2	119) 1063)

TABLE 2B.Sample List - 1937-38.

No.	Date	Place of Capture	Number of Fish
<u>1937:</u>			
1	Oct. 19	Clarence River	30
2	" 27	" "	29
3	Nov. 9	" "	24
4	" 16	" "	24
5	" 23	" "	30
6	Dec. 8	" "	38
7	" 27	" "	30
<u>1938:</u>			
8	Jan. 5	" "	30
9	" 13	" "	39
10	" 18	" "	30
11	" 25	" "	30
12	Feb. 9	" "	24
13	" 16	Camden Haven	36
14	" 24	Clarence River	31
15	Mch. 3	Cronulla	24
16	Feb. 14	Twofold Bay	6
17	" 15	Merimbula Lake	27
18	" 17	Wallaga Lake	36
19	" 18	Tuross Lake	69
20	" 19	" "	55
21	" 20	Glyde River	25
22	" 20	" "	9
23	" 21	Cullendulla Creek	16
24	" 21	" "	41
25	" 23	Glyde River	82
26	" 24	Currambene Creek	46
27	" 24	Crookhaven	43
28	" 24	"	40
29	Mch. 18	Tuross Lake	22
30	" 19	Maclean	30
31	" 18	Huskisson	50
32	" 25	Cronulla	100
33	" 26	Hawkesbury River	30
34	" 29	St. George's Basin	20
35	" 29	" " "	55
36	" 29	Laurieton	50
37	" 31	Iluka	72

TABLE 2B. (Contd.)

No.	Date	Place of Capture	Number of Fish
38	Apl. 1	Yamba	68
39	" 4	Leet's Vale	86
40	" 5	Port Kembla	55
41	" 6	Iluka	72
42	" 10	"	79
43	" 10	Nelson's Bay	46
44	" 10	Cronulla	192
45	" 12	Yamba	52
46	" 13	Jervis Bay	50
47	" 20	Clarence River	54
48	" 20	" "	61
49	" 26	" "	29
50	" 29	Taree	66
51	May 2	Cronulla	40
52	" 4	Maclean	20
53	" 16	South Grafton	28
54	Apl. 30	Cronulla	169
55	May 17	Clarence River	89
56	" 17	Iluka	20
57	" 19	Iluka	60
58	June 14	Lake Conjola	43
59	" 20	Birrroul	139
60	" 24	Bateman's Bay	50
61	" 24	Wyang	55
62	" 26	Wyang	74
63	" 27	Laurieton	57
64	July 5	Nowra	52
65	" 8	Nowra	54
66	" 8	Nowra	21
67	Nov. 30	Grafton	75
68	Dec. 11	Cullendulla Creek	22
69	" 12	Clyde River	7
70	" 12	Crookhaven River	71

TABLE 2C.

Sample List - 1939.

No.	Date	Place of Capture	Number of Fish
<u>1939:</u>			
1	Jan. 26	Clarence River	48
2	" 27	Tweed River	24
3	" 30	Tweed Head	95
4	" 31	Tewantin	31
5	Feb. 1	Moreton Bay	14
6	" 1	Moreton Bay	13
7	" 1	Moreton Bay	16
8	" 3	Moreton Bay	25
9	" 6	Hervey Bay	12
10	" 8	Clarence River	25
11	" 23	Laurieton	50
12	" 23	Wyong	6
13	" 28	Burrill Lake	47
15	Moh. 3	Port Macquarie	5
16	" 3	Laurieton	52
17	" 3	Botany	50
18	" 7	Port Kembla	47
21	" 9	Nelson's Bay	31
22	" 10	Port Jackson	62
23	" 10	Nelson's Bay	33
24	" 14	Hawkesbury	66
25	" 16	Huskisson	18
26	" 21	Wyong	45
27	" 24	Nelson's Bay	32
28	" 28	Laurieton	50
29	" 30	Spencer	29
30	" 31	Wyong	40
31	Apl. 11	Wyong	55
32	" 13	Laurieton	46
33	" 14	Jervis Bay	50
34	" 18	Port Macquarie	43
35	" 20	Patonga	36
36	" 21	Nelson's Bay	30
PH1	" 26	Port Hacking	100
N1	" 27	Clarence River	50
PH2	May 1	Port Hacking	114
37	" 4	Wyong	25
N2	" 5	Richmond River	30
N3	" 6	Richmond River	46
38	" 9	South West Rocks	30
39	" 16	Wyong	50
40	" 18	Wyong	50
41	" 19	Wyong	50

TABLE 2C. (Contd.)

No.	Date	Place of Capture	Number of Fish
42	May 23	Maclean	50
43	" 31	Wyong	62
44	June 6	Maclean	40
45	" 6	Wyong	50
46	" 15	Tuncurry	100
47	" 20	Wyong	70
48	" 20	Maclean	50
N4	" 30	Moolooloobah	100
N5	July 3	Double Head	12
N6	" 3	Yeppoon	43
48	" 5	Forster	33
N7	" 7	"	72
N8	" 12	Pialba	37
N9	" 12	Maryborough	48
N10	" 12	Bribie Passage	70
49	Aug. 1	Nowra	9
PH3	" 3	Port Hacking	60
PH4	" 6	Port Hacking	14
50	" 8	Windsor	40
51	" 15	Dora Creek	50
52	" 18	Dapto	50
53	" 22	Grafton	37
S.1	" 24	Upstream from Cement, Clyde River	52
S.2	" 25	Narooma	25
54	" 29	Dapto	50
55	Sep. 8	A South Coast lake	50
PH6	" 29	Gunnamatta Bay	25
PH7	" 20	Salmon haul, Port Hacking	165
PH8	Oct. 5	Port Hacking	47
S.3.	" 14	Narooma	22
56	Nov. 1	Laurieton	50
57	" 3	Wiseman's Ferry	33
58	" 7	Dora Creek	50
PH9	" 8	" "	235
59	" 10	Windsor	50
60	" 20	Wyee	25
PH11	Dec. 4	"	6
61	" 7	Laurieton	50
62	" 19	Dora Creek	50
S.4.	" 20	" "	12
S.5	" 21	" "	2
63	" 29	Kendall	44

TABLE 2D.

Sample List - 1940

A. Detailed Samples.

Date	Locality	Number of Fish	Total
3.1.40	Tuggerah Lakes	14	
18.1.40	Manning River	129	
18.1.40	Harrington	65	
19.1.40	Nambucca R.	5	
24.1.40	Richmond R.	31	
25.1.40	Tweed R.	29	
26.1.40	Laurieton	50	
31.1.40	Laurieton	50	
2.2.40	Maroochydore	5	
26.2.40	Lake Macquarie	11	10 - 389

B. Samples consisting of measurements of length only

Month	Locality	Number of Samples	Number of Fish	TOTAL Samples	Fish
January	Maclean	2	345	2	345
February	Noosa R.	1	160		
	Coomera R.	1	84		
	Wynnum	1	69		
	Clarence R.	3	233	6	546
March	Port Hacking	1	385	1	385
April	Clarence R.	10	1212		
	Macleay R.	3	153		
	Wallis Lake	2	218		
	Tuggerah Lakes	10	581		
	Port Hacking	7	2130		
	Shoalhaven R.	1	58		
	Ulladulla	2	591	35	4943
May	Clarence R.	19	2240		
	Nambucca R.	1	55		
	Wallis Lake	2	242		
	Newcastle	1	34		
	Tuggerah Lakes	6	489		
	Shoalhaven R.	3	239	32	3299
June	Clarence R.	4	434	4	434
July	Clarence R.	7	801		
	Wallis Lake	2	225		
	Tuggerah Lakes	5	382		
	Shoalhaven R.	1	93		
	St. George's Basin	1	43	16	1544
August	Clarence R.	7	759		
	Manning R.	1	106		
	Southgate	1	89	9	954
September	Clarence R.	1	137	1	137
October	Clarence R.	8	883		
	Nambucca R.	1	100		
	Manning R.	1	72		
	Tuggerah Lakes	2	216	12	1271
November	Clarence R.	3	405		
	Cape Hawke	1	112	4	517
December	Clarence R.	2	245	2	245
				124	14,620

TABLE 2E.

Sample List for 1941 (January to June).

A. Detailed Samples.

Date	Locality	Number of Fish	Total
8.1.41	Wagonga R.	18	
16.1.41	Port Hacking	12	
3.4.41	Hawkesbury R.	35	
7.4.41	Port Jackson	40	
10.4.41	--	25	
18.4.41	Stockton	25	
29.4.41	Grafton	10	
30.4.41	Kempsey	19	
1.5.41	Grafton	25	
5.5.41	Hawkesbury R.	25	
6.5.41	Hawkesbury R.	25	
9.5.41	Clarence R.	25	
15.5.41	Terranorra Ck.	14	
28.5.41	Nowra	42	
13.6.41	Maclean	25	
26.6.41	Maclean	50	16 - 415

B. Samples consisting of measurements of length only.

Month	Locality	Number of	Number of	TOTAL	
		Samples	Fish	Samples	Fish
January	Nambucca R.	3	215		
	Bellinger R.	1	123		
	Manning R.	1	100		
	Wallis Lake	1	16		
	Woonona Bay	1	73		
	Port Hacking	1	104		
	Lake Illawarra	1	100		
	Greenwell Pt.	1	45	10	776
February	Clarence R.	2	204		
	Manning R.	3	362		
	Wallis Lake	1	111		
	Port Hacking	1	641		
	Lake Illawarra	1	76		
	Shoalhaven R.	1	62		
	Huskisson	1	54	10	1510
March	Clarence R.	5	427		
	Manning R.	5	259		
	Wallis Lake	1	69		
	Lake Macquarie	1	211		
	Tuggerah Lakes	3	172		
	Port Jackson	1	47		
	Port Hacking	1	40	17	1225
April	Clarence R.	31	3554		
	Nambucca R.	5	586		
	Macleay R.	7	871		
	Hastings R.	1	37		
	Camden Haven	1	48		
	Manning River	15	1037		
	Wallis Lake	8	575		
	Hunter R.	1	112		
	Tuggerah Lakes	15	955		
	Hawkesbury R.	8	605		
	Port Hacking	2	184		
	Port Kembla	1	239		
	Lake Illawarra	2	119		

Contd.

TABLE 2E. (Contd.)

Month	Locality	Number of Samples	Number of Fish	TOTAL	
				Samples	Fish
April (Contd.)	Shoalhaven R.	2	187		
	Wreck Bay	1	194		
	Burrill Lake	2	204		
	Unknown origin	5	161	107	9668
May	Tweed R.	4	676		
	Richmond R.	1	35		
	Clarence R.	34	3707		
	Coff's Harbour	1	54		
	Nambucca R.	3	610		
	Macleay R.	2	110		
	Hastings R.	1	54		
	Manning R.	2	133		
	Wallis Lake	3	357		
	Tuggerah Lakes	10	1163		
	Hawkesbury R.	3	530		
	Lake Illawarra	4	504		
	Shoalhaven R.	4	491		
	Jervis Bay	1	23		
	Unknown origin	2	148	75	8595
June	Clarence R.	7	816		
	Macleay R.	3	452		
	Camden Haven	1	75		
	Manning R.	3	223		
	Wallis Lake	9	1141		
	Tuggerah Lakes	6	659		
	Lake Illawarra	4	716		
	Shoalhaven R.	4	396		
	Jervis Bay	5	400		
	Milton	1	39		
	Tilba	1	87		
	Unknown origin	1	103	45	5107
				264	26,881

TABLE 2F.

Sample List.

Western Australian Measurements.

A. Detailed Samples.

Date	Locality	Number of Fish	Total
<u>1939</u>			
3.4.39	Peel Inlet	23	
28.4.39	Swan River	76	
27.7.39	Shark Bay	155	
20.9.39	Shark Bay	8	
30.9.39	Shark Bay	10	
13.10.39	Mandurah	6	
25.10.39	Swan River	23	
25.10.39	Murchisson River	6	
3.12.39	Wilson's Inlet	21	9 - 328
<u>1940</u>			
6.2.40	Franklin R.	41	
2.40	Nannarup	7	
24.2.40	Swan River	11	
2.4.40	Mandurah	12	
10.4.40	Augusta	11	
29.4.40	Mandurah	12	
2.5.40	Mandurah	30	
23.5.40	Mandurah	151	
7.6.40	Mandurah	66	9 - 341

TABLE 2F. (Contd.)

Date	Locality	Number of Fish	Total
<u>1941</u>			
1.4.41	Mandurah	36	
2.4.41	Swan River	49	
26.4.41	Murray R.	15	
11.5.41	Shark Bay	193	
17.5.41	Bowes R.	10	5 - 305

B. Samples consisting of measurements of length only.

Month	Locality	Number of Samples	Number of Fish	TOTAL Samples Fish	
<u>1940</u>					
April	Augusta	1	158		
	Mandurah	1	305		
	City Beach	1	160		
	Scarborough Beach	1	85	4	708
May	Mandurah	25	4959		
	Denmark	1	55		
	Augusta	1	155	27	5129
June	Mandurah	8	2773		
	Murchisson	1	52		
	Augusta	1	51	10	2856
<u>1941</u>					
February	Swan River	6	1024		
	Margaret R.	1	214		
	Wilson's Inlet	2	119		
	Whitford's Beach	2	516		
	Augusta	1	84		
	Shark Bay	1	20		
	Bussellton	1	93		
	Albany	2	102	16	2172
March	Swan River	3	520		
	Margaret R.	2	144		
	Wilson's Inlet	1	655		
	Whitford's Beach	2	735		
	Augusta	2	493		
	Bussellton	1	151		
	Mandurah	5	1690	16	4366
April	Swan River	1	41		
	Margaret R.	2	289		
	Augusta	1	164		
	Bussellton	1	347		
	Albany	1	358		
	Bunbury	1	149		
	Mandurah	4	878	11	2206
May	Augusta	1	80		
	Shark Bay	1	193		
	Bunbury	1	313		
	Mandurah	1	204		
	Chapman R.	1	88		
	Geraldton Harbour	1	45		
	Greenough R.	1	50	7	973
June	Wilson's Inlet	1	231		
	Augusta	1	246		
	Albany	2	295		
	Bunbury	1	174		
	Mandurah	5	2018	10	2964
				101	21,594

TABLE 3A. - BODY PROPORTIONS.

Head length, Trunk length and Tail length as percentages of Total length. O+ and I+ fish.

GRAND MEAN: $\frac{100 \text{ HL}}{\text{TL}} = 20.81$ GRAND MEAN: $\frac{100 \text{ TrL}}{\text{TL}} = 35.20$ GRAND MEAN: $\frac{100 \text{ CL}}{\text{TL}} = 45.21$

Sample No.	Origin	Date	No. in Sample	Mean Length	Mean $\frac{100 \text{ HL}}{\text{TL}}$	Sample Mean - Grand Mean	Sample Range	Mean $\frac{100 \text{ TrL}}{\text{TL}}$	Sample Mean - Grand Mean	Sample Range	Mean $\frac{100 \text{ CL}}{\text{TL}}$	Sample Mean - Grand Mean	Sample Range
1	Manning River	22.11.37	11	6.56	22.00	+1.19	3.4	32.4	-0.80	4.6	45.60	+0.41	5.0
2	Tweed River	29.11.37	11	13.88	19.76	-1.05	2.3	34.17	+0.97	4.6	46.06	+0.85	3.3
3	Tweed River	12.12.37	14	6.43	21.02	+0.21	4.0	33.83	+0.63	6.5	45.25	+0.04	5.0
4	Tweed River	28.12.37	16	7.18	23.11	+2.30	2.6	33.11	-0.09	2.5	43.79	-1.42	3.9
5	Tea Gardens	1.1.38	63	5.67	22.22	+1.41	6.8	32.85	-0.35	8.5	44.87	-0.34	9.4
6	George's River	4.1.38	25	10.20	21.63	+0.82	2.4	33.15	-0.05	5.7	44.89	-0.32	6.8
7	Wagonga River	11.2.38	11	9.20	19.90	-0.91	2.3	34.90	+1.70	3.3	44.85	-0.36	3.1
8	Manning River	16.1.40	64	7.81	20.19	-0.62	3.2	33.26	+0.06	9.7	46.64	+1.43	8.9
9	Tweed River	25.1.40	64	9.67	20.19	-0.62	3.9	33.98	+0.78	4.5	45.79	+0.58	4.7
10	Moreton Bay	31.1.40	11	16.91	17.73	-3.08	2.2	34.60	+1.40	4.6	47.37	+2.16	3.4
11	Clarence River	7.2.40	96	9.20	20.79	-0.02	5.3	32.83	-0.37	7.3	45.25	+0.04	5.6
12	Noosa River	18.6.40	23	13.18	20.54	-0.27	3.7	33.84	+0.64	3.9	45.75	+0.54	3.1
13	Richmond River	27.6.40	25	14.33	20.55	-0.26	2.6	32.91	-0.29	8.5	46.55	+1.34	6.8
14	Lake Illawarra	11.1.41	61	9.86	20.85	+0.04	3.4	34.00	+1.80	5.2	44.91	-0.30	7.1
15	Hawkesbury River	19.3.41	110	11.81	20.72	-0.09	5.7	33.27	+0.07	6.2	45.76	+0.55	6.7

TABLE 3B. - BODY PROPORTIONS.

Head length, Trunk length and Tail length as percentages of Total length. II and older fish.

GRAND MEAN: $\frac{100 \text{ HL}}{\text{TL}} = 18.64$ GRAND MEAN: $\frac{100 \text{ TrL}}{\text{TL}} = 35.36$ GRAND MEAN: $\frac{100 \text{ CL}}{\text{TL}} = 45.93$

Sample No.	Origin	Date	No. in Sample	Mean Length	Mean $\frac{100 \text{ HL}}{\text{TL}}$	Sample Mean - Grand Mean	Sample Range	Mean $\frac{100 \text{ TrL}}{\text{TL}}$	Sample Mean - Grand Mean	Sample Range	Mean $\frac{100 \text{ CL}}{\text{TL}}$	Sample Mean - Grand Mean	Sample Range
3	Tweed Heads	30.1.39	17	32.33	19.50	0.86	2.30	33.69	-1.67	5.03	46.72	0.79	4.38
4	Tewantin	31.1.39	31	34.77	19.47	0.83	3.41	35.39	0.03	5.14	45.22	-0.71	6.11
5	Moreton Bay	1.2.39	14	32.61	20.18	1.54	3.23	33.60	-1.76	5.85	46.28	0.35	5.01
6	"	1.2.39	13	33.92	19.65	1.01	2.84	33.04	-2.32	5.21	47.31	1.38	4.44
7	"	1.2.39	16	30.69	19.86	1.22	2.12	32.84	-2.52	3.81	47.49	1.56	4.02
8	"	3.2.39	25	33.32	19.83	1.19	2.70	33.08	-2.28	4.90	46.33	0.40	4.00
9	Hervey Bay	6.2.39	12	39.71	19.83	1.19	2.70	34.95	-0.41	3.90	45.23	-0.70	2.20
10	Maclean	8.2.39	25	38.15	20.04	1.40	1.70	35.76	0.40	3.40	45.59	-0.34	4.00
11	Laurieton	23.2.39	50	32.27	20.13	1.49	8.50	33.54	-1.82	11.90	46.02	0.09	18.30
12	Wyong	23.2.39	6	34.96	20.31	1.67	2.44	34.17	-1.19	4.41	45.94	0.01	4.96
13	Burrill Lake	28.2.39	47	40.44	19.82	1.18	3.10	34.87	-0.49	4.50	45.16	-0.77	4.50
15	Pt. Macquarie	3.3.39	5	38.56	20.10	1.46	2.06	35.75	0.39	4.42	46.19	0.26	6.60
16	Laurieton	3.3.39	52	35.37	19.86	1.22	2.5	34.65	-0.71	8.50	45.70	-0.23	8.10
17	Botany	3.3.39	10	28.63	19.54	0.90	2.24	34.39	-0.97	8.10	45.66	-0.27	2.28
18	Pt. Kembla	7.5.39	47	42.26	19.35	0.71	3.1	35.50	0.14	7.10	45.25	-0.68	7.60
21	Nelson's Bay	9.3.39	31	43.8	19.27	0.63	2.71	34.83	-0.53	6.86	45.86	-0.07	7.58
22	Pt. Jackson	10.3.39	62	27.85	20.20	1.56	3.40	33.92	-1.44	5.63	45.59	-0.34	6.25
23	Nelson's Bay	10.3.39	33	40.66	19.33	0.69	2.46	34.56	-0.80	7.63	45.78	-0.15	4.62
24	Hawkesbury River	14.3.39	66	35.78	19.71	1.07	3.44	35.00	-0.86	8.35	45.42	-0.51	5.86

(Contd.)

TABLE 3B. - BODY PROPORTIONS (Contd.)

Sample No.	Origin	Date	No. in Sample	Mean Length	Mean 100 HL TL	Sample Mean - Grand Mean	Sample Range	Mean 100 TrL TL	Sample Mean - Grand Mean	Sample Range	Mean 100 CL TL	Sample Mean - Grand Mean	Sample Range
25	Huskisson	16.3.39	18	44.41	17.58	-1.06	1.60	37.51	2.15	5.08	44.85	-1.08	5.13
26	Wyong	21.3.39	45	35.00	17.81	-0.83	1.36	35.50	0.34	5.62	46.73	0.80	5.40
27	Nelson's Bay	21.3.39	32	43.44	17.84	-0.80	2.90	37.16	1.80	6.07	45.51	-0.42	4.93
28	Laurieton	28.3.39	50	30.30	18.91	0.25	3.60	35.08	-0.28	5.80	46.11	0.18	6.50
29	Hawkesbury River	30.3.39	45	38.35	18.05	-0.61	3.80	36.53	1.16	4.30	46.06	0.13	5.00
30	Wyong	31.3.39	40	36.50	17.45	-1.21	4.60	36.24	0.88	6.10	46.63	0.70	4.10
31	"	11.4.39	55	35.11	19.12	0.48	5.40	34.79	-0.57	6.70	46.44	0.51	5.10
32	Laurieton	13.5.39	46	35.00	18.92	0.28	4.40	35.13	-0.23	5.40	46.77	0.84	7.90
33	Jervis Bay	14.4.39	50	36.88	18.60	-0.04	3.70	35.57	0.21	4.80	45.66	-0.27	5.50
34	Pt. Macquarie	18.4.39	43	46.13	18.44	-0.20	3.10	34.70	-0.66	7.80	46.63	0.70	6.40
35	Hawkesbury River	20.4.39	36	43.06	18.66	0.02	3.58	35.10	-0.26	7.02	46.02	0.09	5.17
36	Nelson's Bay	21.4.39	30	43.56	18.82	0.18	2.99	36.62	0.28	7.22	44.47	-1.46	5.51
37	Wyong	4.5.39	25	48.47	16.91	-1.73	3.24	38.15	2.79	5.96	44.78	-1.15	5.42
38	Sth. West Rocks	9.5.39	30	42.61	17.91	-0.73	3.90	35.75	0.39	6.80	46.98	1.05	4.60
39	Wyong	13.5.39	50	32.84	17.63	-1.01	5.80	35.28	-0.08	7.90	47.09	1.16	4.20
40	"	18.5.39	50	34.72	17.54	-1.10	6.70	35.05	-0.31	5.60	46.09	0.16	8.10
41	"	19.5.39	50	32.85	17.76	-0.88	1.70	35.19	-0.17	3.90	47.04	1.11	7.80
42	Maclean	23.5.39	50	25.03	17.43	-1.21	2.20	35.62	0.26	5.40	46.90	0.97	4.40
43	Wyong	31.5.39	69	32.96	16.99	-1.65	2.20	35.37	0.01	6.30	47.66	1.73	4.90
44	Maclean	6.6.39	40	34.26	18.32	-0.32	2.90	35.95	0.59	6.80	45.42	-0.51	7.10
46	Tuncurry	15.6.39	50	33.68	17.67	-0.97	2.40	35.10	-0.26	4.30	47.25	1.32	4.60
47	Wyong	20.6.39	70	32.60	17.61	-1.03	4.57	34.68	-0.68	5.60	47.53	1.60	4.9
48	Forster	5.7.39	33	30.95	18.76	0.12	5.60	34.27	-1.09	7.20	46.93	1.00	4.6

TABLE 4A.

Weight Length Relation.Mean weight at each centimetre of total length.

Length		FEMALE			MALE			ALL FISH		
		No.	Mean Weight		No.	Mean Weight		No.	Mean Weight	
0.01L ³	cm.		oz.	g.		oz.	g.		oz.	g.
0.01	1									
0.08	2									
0.27	3				2	0.017	0.48	2	0.017	0.48
0.64	4				4	0.036	1.01	4	0.036	1.01
1.25	5				35	0.07	2.07	35	0.070	2.07
2.16	6				26	0.10	2.83	26	0.10	2.83
3.43	7				21	0.13	3.81	21	0.13	3.81
5.12	8				49	0.17	4.96	49	0.17	4.96
7.29	9				25	0.26	7.27	25	0.26	7.27
10.00	10				14	0.35	10.00	14	0.35	10.00
13.31	11				8	0.54	15.29	8	0.54	15.29
17.28	12				6	0.77	21.87	6	0.77	21.87
21.97	13									
27.44	14									
33.75	15				7	1.37	38.72	7	1.37	38.72
40.96	16				7	1.44	40.78	7	1.44	40.78
49.13	17				10	1.88	53.43	10	1.88	53.43
58.32	18				12	2.16	61.16	12	2.16	61.16
68.59	19				13	2.50	70.96	13	2.50	70.96
80.00	20	1	2.79	79.00	11	3.02	85.66	12	3.00	85.11
92.61	21				17	3.38	95.84	17	3.38	95.84
106.48	22				18	4.24	120.08	18	4.24	120.08
121.67	23				11	4.54	128.70	11	4.54	128.70
138.24	24	1	4.86	137.70	20	4.97	141.00	21	5.00	140.84
156.25	25	3	5.63	159.70	12	5.77	163.67	15	5.74	162.87
175.76	26	3	6.11	173.33	24	6.38	180.85	27	6.35	180.00
196.80	27	7	7.14	202.42	38	6.97	197.60	45	6.95	197.03
219.50	28	8	8.07	228.78	40	7.68	223.40	48	7.91	224.25
243.90	29	20	8.74	247.78	39	8.65	245.23	59	8.68	246.08
270.00	30	22	9.73	275.85	47	9.51	269.61	69	9.58	271.59
297.90	31	60	10.77	305.33	70	10.54	298.81	130	10.65	301.93
327.70	32	87	11.92	337.93	130	11.71	331.98	207	11.80	334.53
359.40	33	134	12.80	362.88	185	12.44	352.67	319	12.58	356.93
393.00	34	143	13.98	396.33	216	13.56	384.43	359	13.72	388.96
428.80	35	123	15.18	430.35	216	14.94	423.55	339	15.03	426.10
466.6	36	113	16.41	465.22	190	16.18	458.70	303	16.30	462.10
506.5	37	95	18.08	512.57	175	17.58	498.39	270	17.75	503.21
548.7	38	67	19.18	545.75	169	19.06	540.35	236	19.10	541.49
593.2	39	55	21.35	605.28	163	21.25	602.44	218	21.32	604.42
640.0	40	63	23.06	653.75	129	23.24	568.85	142	23.18	657.15
689.2	41	50	25.24	715.55	120	25.10	711.59	170	25.14	712.72
740.9	42	47	26.85	761.48	96	28.26	801.17	143	27.80	788.13
795.1	43	52	29.64	840.29	62	29.82	845.40	114	29.74	843.13
851.8	44	48	32.29	915.42	40	32.01	907.48	88	32.16	911.74
911.3	45	47	34.73	984.60	29	33.00	935.55	78	34.34	973.54
973.4	46	46	37.07	1050.93	18	36.73	1041.30	54	36.98	1048.38
1038.2	47	45	40.49	1147.89	16	37.77	1070.78	61	39.81	1128.61
1105.9	48	35	43.00	1219.05	4	40.25	1141.09	39	42.72	1211.11
1176.5	49	37	45.30	1284.26	5	42.15	1194.95	42	44.93	1273.77
1250.0	50	21	48.21	1366.75	3	42.42	1202.61	24	47.51	1346.34
1326.5	51	15	51.34	1455.49	3	47.37	1342.94	17	47.96	1359.97
1406.1	52	16	56.98	1615.38				16	56.98	1615.38
1488.8	53	9	58.40	1655.64				9	58.40	1655.64
1574.6	54	6	61.10	1732.19				6	61.10	1732.19
1663.8	55	5	67.80	1922.13				5	67.80	1922.13
1756.2	56	6	69.21	1962.10				6	69.21	1962.10
1851.9	57	7	71.90	2038.37				7	71.90	2038.37
1951.1	58	2	79.50	2253.83				2	79.50	2253.83
2053.8	59	2	75.20	2131.72				2	75.20	2131.92

TABLE 4B.

Mean Values for K and for Proportional Weights for a representative series of samples.

Sample No.	Origin	Date	No. in Sample	Mean Length	$K = \frac{\text{Mean } W}{0.01L^3}$	Gonad Condition	$\frac{100 \text{ Gtd. Wt.}}{WW}$	$\frac{100 \text{ Gut } WW}{WW}$	$\frac{100 \text{ Gnd. Wt.}}{WW}$
1	Clarence River	26.1.39	48	54.56	0.09	II, III			
2	Tweed River	27.1.39	24	27.39	1.06	I, II			
3	Tweed River	29.1.39	95	52.33	0.99	II			
4	Tewantin	31.1.39	31	54.77	1.05	II			
5	Moreton Bay	1.2.39	14	33.57	0.96	I, II			
6	"	1.2.39	13	33.92	0.95	II			
7	"	1.3.39	16	30.69	0.92	I, II			
8	"	3.2.39	25	33.32	0.99	I, II			
9	Hervey Bay	6.2.39	12	39.71	1.00	II			
10	Clarence River	8.2.39	25	38.15	1.02	II			
11	Laurieton	23.2.39	50	32.27	1.03	I, II	90.27	8.75	
12	Wyong	23.2.39	6	34.96	1.18	I, II	90.50	9.44	
13	Burrill Lake	28.2.39	47	40.40	1.17	II, III	91.45	8.35	
15	Pt. Macquarie	3.3.39	5	38.56	1.11	I, II, III	89.10	10.88	
16	Laurieton	3.3.39	52	35.37	1.06	I, II, III	89.64	10.36	
17	Botany	3.3.39	50	31.57	1.07	I	88.76	11.24	
18	Pt. Kembla	7.3.39	47(32 (15	30.98 47.40	1.15 1.15	I, II, III III, IV	88.27 90.39	7.75 7.45	2.19
21	Nelson's Bay	9.3.39	29(16 (13	42.18 45.98	1.07 1.13	II, III III, IV	89.03 91.18	6.35 5.27	3.60

TABLE 4B. (Contd.)

Mean Values for K and for Proportional Weights for a representative series of samples.

Sample No.	Origin	Date	No. in Sample	Mean Length	$K = \frac{\text{Mean } W}{0.01L^3}$	Gonad Condition	$\frac{100 \text{ Gtd. Wt.}}{WW}$	$\frac{100 \text{ Gut}}{WW}$	$\frac{100 \text{ Gnd. Wt.}}{WW}$
22	Pt. Jackson	10.3.39	82	35.24	1.00	I	91.08	8.90	
23	Nelson's Bay	10.3.39	31(27 4	42.08 43.28	1.09 1.08	II, III III, IV, V	93.25 91.92	6.78 5.33	2.76
24	Hawkesbury R.	14.3.39	66(64 2	50.6 35.3	1.09 1.19	I, II, III III, V	93.15 90.56	6.52 5.29	4.16
25	Huskisson	16.3.39	18	44.42	1.13	II, III, IV	92.60	6.47	0.88
26	Wyong	21.3.39	45	35.00	1.06	I, II, III	91.89	8.81	
27	Nelson's Bay	24.3.39	32	43.44	1.14	II, III, IV, V, VI	87.16	6.83	6.20
28	Laurieton	28.3.39	50(49 1	30.13 38.80	1.05 0.97	I, II, III, IV II	88.63 88.09	11.37 10.50	1.86
29	Spencer	30.3.39	45	38.35	1.09	I, II, III	92.07	7.93	
30	Wyong	31.3.39	39(28 11	34.43 31.47	1.10 1.15	I, II, III IV, V, VI	90.80 89.05	9.20 5.76	5.18
32	Laurieton	13.4.39	43(36 7	32.67 45.53	0.99 1.08	I, II, III III, IV, V, VI	91.15 87.83	8.91 6.55	6.19
33	Jervis Bay	14.4.39	42(40 2	36.60 41.60	1.05 1.01	I, II, III, IV III, VI	93.85 92.49	5.81 5.87	3.89
34	Pt. Macquarie	18.4.39	42	38.52		IV, V, VI	90.1	5.92	11.13
35	Patonga	20.4.39	40	43.06	0.98	V	87.07	4.01	9.60

35	Nelson's Bay	21.4.39	29 (1 28)	39.40 43.74	0.95 1.08	II III, IV, V	91.50 87.03	8.55 5.05	7.74
37	Wyong	4.5.39	25 (3 22)	45.53 48.87	1.09 1.09	II II, IV, V, VI	93.94 88.77	6.06 4.42	6.80
38	South West Rocks	9.5.39	30	42.61	1.03	IV, V, VI	83.55	4.29	12.71
39	Wyong	16.5.39	49 (48 1)	32.98 37.10	1.00 1.02	I, II III	92.09 89.06	7.91 8.20	-
40	Wyong	18.5.39	50	34.72	1.01	I, II	92.34	7.66	2.74
41	Wyong	19.5.39	46	32.88	1.01	I, II	94.71	8.17	-
42	Maclean	23.5.39	50 (44 6)	34.70 37.37	1.03 1.13	I, II, III V, VI, VIII	90.55 87.92	9.41 8.40	-
43	Wyong	31.5.39	64	33.08	1.03	I, II	91.77	8.19	3.74
44	Maclean	4.6.39	40 (39 1)	34.21 36.20	1.03 1.05	I, II, IV II	90.03 91.26	9.46 4.4	-
45	Wyong	6.6.39	49	33.52	1.08	I, II	92.29	7.70	4.34
46	Tuncurry	15.6.39	100	37.00	0.97	I	92.10	7.80	-
47	Wyong	20.6.39	70 (67 3)	32.68 34.00	0.99 0.98	I I	92.39 90.30	7.75 8.92	-
48	Maclean	20.6.39	50	33.63	1.01	I, II, V	-	-	7.83
48a	Forster	5.7.39	33	30.95	0.94	I	92.05	7.90	-

Where the gonads of any fish in a sample were large enough to be weighed, such fish were entered separately in this Table, from the other fish of the sample.

TABLE 5A. (Contd.)

Sample No:		Origin:		Sample No:		Origin:	
12		Port Hacking		18		Port Hacking	
13		Lake Macquarie		19		Port Hacking	
14		Port Hacking		20		Port Hacking	
15		Port Hacking		21		Manning River	
16		Noosa River		22		Tweed River	
17		Richmond River					

	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
Cms.	5.03	5.03	5.03	6.03	18.6.40	27.6.40	2.8.39	20.9.39	5.10.39	22.11.37	28.12.37
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6	1	-	-	-	-	-	-	-	-	4	2
7	2	-	-	-	-	-	-	-	-	6	13
8	12	3	5	14	-	-	-	-	-	1	3
9	10	45	37	71	-	-	-	-	1	-	2
10	4	338	49	32	1	-	-	-	2	-	1
11	4	715	7	2	-	-	-	-	4	-	-
12	-	662	-	-	5	2	-	-	2	-	-
13	-	435	-	-	10	9	-	-	1	-	-
14	-	255	-	-	3	10	1	-	1	-	-
15	1	123	-	-	3	2	7	1	1	-	-
16	1	57	-	-	1	1	7	-	2	-	-
17	2	30	-	-	-	1	7	5	4	-	-
18	1	36	-	-	-	-	2	7	6	-	-
19	1	56	-	-	-	-	1	3	3	-	-
20	-	69	-	-	-	-	3	3	8	-	-
21	-	106	-	-	-	-	-	-	2	-	-
22	-	110	-	-	-	-	-	1	9	-	-
23	-	107	-	-	-	-	-	1	-	-	-
24	-	76	-	-	-	-	2	1	-	-	-
25	-	56	-	-	-	-	2	-	-	-	-
26	-	36	-	-	-	-	8	-	1	-	-
27	-	15	-	-	-	-	8	-	-	-	-
28	-	-	-	-	-	-	7	-	-	-	-
29	-	-	-	-	-	-	3	-	-	-	-
30	-	-	-	-	-	-	1	-	-	-	-
Total:	39	5330	98	119	23	25	59	22	47	11	21
Mean Lengths	8.8	12.0	9.6	9.2	-	-	-	-	11.0	4.9	6.7
I+	-	21.9	-	-	13.2	13.8	16.6	18.1	19.4	-	-
II+	-	-	-	-	-	-	26.9	-	-	-	-

TABLE 5B.

Measurements (Total Length).
All Waters - Eastern Australia, 1937-38.

Cm.	1937				1938					
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	May	June	Nov.
20										
21										
22										
23							1			
24							-			
25							-			
26							-			
27					2		-			
28					-		1			
29					-		5			
30	4	4		2	4	4	9	1	1	2
31	9	5	1	5	3	19	16	5	5	4
32	7	11	8	11	6	23	41	13	23	6
33	7	12	8	25	7	36	72	12	25	9
34	9	11	12	36	9	38	87	19	36	10
35	11	6	14	12	10	34	84	24	23	13
36	3	9	9	14	20	35	104	23	27	5
37	4	8	3	8	7	26	90	13	13	1
38	3	8	1	6	2	26	84	13	19	2
39	1	2	1	6	5	22	78	22	10	
40	-	-	-	2	4	11	67	8	2	
41	-	1	1	1	3	11	77	11	-	
42	-	-	2	1	2	-	46	6	-	
43	1	2			2	3	21	9	-	
44					2	3	23	14	-	
45					-	4	10	6	-	
46					1	3	22	7	1	
47						2	13	11	-	
48						3	6	8	1	
49						1	6	3		
50						1	6	3		
51							4	1		
52							1	4		
53							1	3		
54										
TOTAL:	59	78	60	129	89	305	975	239	186	52

TABLE 5C.

Measurements (Total Length).
All Waters - Eastern Australia

Cm.	1939										
	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Nov.	Dec.
20								3	3		1
21								-	-		-
22					1			-	1	3	-
23	1		1		-		1	-	1	6	1
24	-		1		-		-	2	1	10	2
25	6	5	7		-		5	5	-	25	-
26	11	3	17	1	-		2	13	5	33	1
27	16	9	43	8	2	4	4	11	12	39	3
28	20	6	47	23	1	2	7	17	37	31	6
29	18	7	20	37	8	1	24	25	56	54	12
30	17	5	14	31	20	14	11	18	34	40	17
31	20	14	23	21	27	40	8	21	16	28	23
32	16	11	8	11	50	56	11	15	5	32	16
33	19	9	32	16	47	68	8	18	-	20	24

(Contd.)

TABLE 5C (Contd.)

1939

Gm.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Nov.	Dec.
34	19	7	31	11	36	68	6	12	1	11	15
35	13	8	22	6	36	41	26	-	1	11	9
36	13	7	22	13	25	29	19	4	-	13	6
37	11	5	19	13	20	22	27	1	1	12	2
38	6	12	23	17	4	15	30	1		15	
39	3	7	31	13	3	13	26	-		13	
40	-	5	31	18		7	16	1		11	
41	2	4	25	11		10	8	1		15	
42	1	3	18	24		2	12			14	
43	-	1	6	15		3	4			3	
44	2	1	11	14		5	5			1	
45		2	2	11		1	4			-	
46		1	6	11		2	-			-	
47		2	4	14		1	3			1	
48			5	4			-				
49			2	4			1				
50			3	5							
51			3	2							
52			2	2							
53											
54											
TOTAL:	214	134	479	356	278	404	268	168	174	441	138

TABLE 5D.

Measurements - (Length to Caudal Fork)
All Waters - Eastern Australia.

1940

Gm.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	No	Dec.
30												
21		1			1		1					
22		1		1	2		1	1		2		
23		11		1	2	1	8	15	2	4		
24		27		11	32	5	35	26	11	30	5	
25		22		77	104	25	85	73	15	63	21	3
26		18	7	277	266	90	208	98	30	134	83	7
27		20	21	446	529	123	353	156	29	208	121	15
28	2	36	25	579	727	110	390	171	21	259	109	51
29	8	38	42	469	617	47	314	166	11	237	80	66
30	20	32	67	459	477	25	215	115	12	143	46	55
31	31	44	94	360	334	6	84	53	-	103	28	26
32	65	45	62	254	187	2	43	31	2	52	10	17
33	106	34	32	155	112	2	21	16	3	17	6	3
34	92	51	19	113	65		8	10	-	9	4	3
35	85	49	11	126	43		8	5	-	7	3	1
36	40	51	3	165	37		5	-	1	2	1	2
37	21	29	1	146	30		3	1		1		
38	13	12	1	138	46		-					
39	5	6	2	123	36		1					
40	8	-	-	84	30							
41	4	1	2	92	30							
42	2	1		67	20							
43				51	29							
44				34	13							
45				19	35							
46				16	43							
47				18	36							
48				18	42							
49				10	25							
50				11	20							
51				3	12							
52				2	4							
53				1	1							
54				2								
TOTAL:	502	529	389	4328	3990	434	1783	937	137	1271	517	249

TABLE 5E.

Measurements - (Length to Caudal Fork).
All Waters - Eastern Australia

1941						
Cm.	Jan.	Feb.	Mar.	Apl.	May	June
20	2		4	15	23	4
21	4		5	29	47	9
22	4		4	21	91	23
23	16	8	4	20	110	76
24	55	19	23	53	167	151
25	105	63	39	184	304	361
26	155	178	61	433	600	594
27	144	241	122	712	910	704
28	136	242	128	818	1076	679
29	120	204	141	966	1014	618
30	105	193	152	911	876	493
31	78	125	150	899	709	319
32	57	103	157	920	593	253
33	30	81	100	802	637	166
34	20	62	88	690	550	107
35	21	44	55	551	447	61
36	9	28	35	400	320	44
37	6	12	28	298	234	11
38	3	4	18	175	196	7
39	2	7	12	144	153	4
40	4	2	14	118	165	1
41	1		12	109	103	
42			6	62	88	
43			-	51	65	
44			3	38	46	
45			1	50	30	
46				42	33	
47				33	25	
48				19	26	
49				23	14	
50				6	4	
51				4	5	
52						
53						
54						
TOTAL: 1077		1616	1362	9576	9661	4685

TABLE 5F.

Measurements - (Length to Caudal Fork).
All Waters - Western Australia, 1939-40.

1939						1940				
Cm.	Apl.	July	Sept.	Oct.	Dec.	Jan.	Feb.	Apl.	May	June
12										2
13									15	12
14									72	15
15									169	6
16									115	1
17							4		48	1
18							2		38	1
19	3						-		2	11
20	7	1				7	26	1	74	24
21	17	1		7	2	7	121	224	1557	911
22	20	14		10	1	8	153	313	1644	1179
23	23	41		8	9	18	92	171	799	538
24	20	34	1	4	8	21	28	105	549	214
25	7	28	1		1	19	22	51	129	104
26	1	14	1			22	33	34	81	58
27	1	15	1			23	54	15	47	32
28		4				29	46	12	30	27
29		2				14	32	4	33	22

(Contd.)

TABLE 5F. (Contd.)

Cm.	1939					1940				
	Apl.	July	Sept.	Oct.	Dec.	Jan.	Feb.	Apl.	May	June
30		1	-			18	40	5	31	15
31			-			8	23	1	32	5
32			1			7	19	1	20	-
33			4			1	20	1	13	1
34			1		1	3	9		9	-
35			1		-	1	14		6	6
36			-		1	3	6		2	8
37				2		2	3		2	5
38			1	-			2		-	4
39			-	-			4		2	5
40			-	-					3	1
41			2	1					3	2
42			-	1					3	3
43			1	-					1	1
44			2	-						2
45				1						2
46			1	-						
47				1						
TOTAL:	99	155	18	35	25	209	752	958	5527	3224

TABLE 5G.

Measurements - (Length to Caudal Fork)
All Waters - Western Australia.

Cm.	1941				
	Feb.	Mar.	Apl.	May	June
20	26	54	6		27
21	355	544	243	158	630
22	461	881	548	233	856
23	317	751	291	113	551
24	185	653	197	25	345
25	156	746	109	25	173
26	60	244	79	51	91
27	39	158	45	70	30
28	12	94	90	57	26
29	39	78	77	37	25
30	20	67	49	13	32
31	75	77	69	5	53
32	23	42	54	2	44
33	14	31	26	1	32
34	13	17	11		17
35	19	13	15		9
36	14	12	23		6
37	12	3	43		7
38	11	0	32		2
39	5	0	14		0
40	3	0	18		4
41	1	1	17		2
42	1	0	27		4
43	58	1	9		3
44	0	6	14		
45	9	3	9		
46	0	5	4		
47	0	6	3		
48	8	4	3		
49	0	19	2		
50	40	13	3		
51	0	13	9		
52	30	15	10		
TOTAL:	2006	4551	2149	790	2969

TABLE 6.Scale Reading from Individual Fish.

Row or Area	Number of Scale	Mean Scale Size cms.	Mean Calculated Lengths				Mean Increment		
			I	II	III	IV	i	ii	iii
<u>Fish (1) Total Length 31.5 cm.</u>									
Row									
II	1	0.50	15.2	25.0			9.8	6.5	
III	1	0.50	14.3	24.5			10.3	7.0	
IV	1	0.46	14.5	25.2			10.7	6.3	
VI	1	0.52	14.4	24.5			10.1	7.0	
VII	5	0.53	14.7	24.6			9.9	6.9	
VIII	6	0.60	14.6	24.6			10.2	6.9	
IX	2	0.58	14.0	24.4			10.4	7.1	
All	17	0.56	14.5	24.6			10.1	6.9	
<u>Fish (2) Total Length 32.9 cm.</u>									
VII	19	0.51	12.7	27.3			14.6	5.9	
VIII	9	0.54	12.5	27.0			14.5	5.9	
IX	3	0.53	12.6	27.2			14.1	6.3	
All	31	0.53	12.6	27.2			14.5	5.9	

TABLE 7.

The number of mullet of each age-group at each centimetre of length. This gives all fish.

Year Group	0	I+	II+	III+	IV+	V+	VI+
Total Caught							
Length in	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.
cms. Year:							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10	3						
11	3						
12	8						
13	1						
14	1						
15	-	5					
16	1	7					
17		13					
18		32					
19		16					
20		14					
21		18					
22		25					
23		15	1				
24		14	1				
25		6	3				
26		3	12				
27		4	21				
28		1	33				
29			43				
30			47	5			
31			89	17			
32			85	17			
33			77	42			
34			52	66	1		
35			30	53	2		
36			19	54	3		
37			12	61	4		
38			3	47	8		
39				41	22		
40				16	22		
41				20	15		
42				13	20	2	
43				7	14	-	
44				7	8	1	
45				1	16	1	
46					8	4	
47					12	1	
48					6	3	
49					7	3	
50					2	1	
51						-	
52						6	
53						1	
54						8	
55						4	
56						3	1
57						3	-
58						1	-
59						1	-
60						1	1

TABLE 8.

Annual Growth.

A. Mean Calculated Intermediate Lengths.

Age Group	l_1		l_2		l_3		l_4		l_5		l_6	
	No.	Mean cm.	No.	Mean cm.	No.	Mean cm.	No.	Mean cm.	No.	Mean cm.	No.	Mean cm.
I+	366	14.45										
II+	678	16.11	607	22.95								
III+	597	13.54	400	22.76	412	31.75						
IV+	156	13.63	154	23.94	151	31.33	156	38.76				
V+	27	14.86	33	24.52	37	35.00	30	41.62	36	47.30		
VI+	15	16.43	9	24.33	21	33.88	21	43.93	8	49.35	20	53.73
All Group	1639	14.86	1203	23.07	621	31.79	207	39.70	44	47.67	20	53.73

B. Mean Calculated Increments.

Age Group	i_1		i_2		i_3		i_4		i_5	
	No.	Mean cm.	No.	Mean cm.	No.	Mean cm.	No.	Mean cm.	No.	Mean cm.
II+	308	10.33								
III+	161	8.96	132	7.27						
IV+	32	10.08	32	6.30	32	6.17				
V+	4	9.13	4	11.20	3	4.97	3	4.90		
VI+	4	8.00	1	9.5	1	12.00	1	9.00	1	3.0
All Group	509	9.86	169	7.19	36	6.23	4	5.73	1	3.0

TABLE 8 (Contd.)

C. Comparison of the growth of the sexes.

Age Group	No.	TL	l ₁	l ₂	Mean Lengths.			l ₅
					l ₃	l ₄		
I+ M	69	24.7	16.0					
F	11	23.5	14.8					
II+ M	343	30.8	15.1	21.5				
F	232	31.7	14.9	23.8				
III+ M	215	37.3	13.7	23.3	31.0			
F	109	34.7	14.1	22.7	30.3			
IV+ M	66	39.5	13.2	23.0	30.0	36.4		
F	37	41.5	13.2	23.5	31.2	37.6		
V+ M	2	41.9	15.3	24.5	30.0	35.0	38.5	
F	2	48.1	13.0	21.3	29.5	37.5	43.0	
All Group	1086		14.55	22.72	30.68	36.81	40.75	

D. Examination of possibility of Lee's Phenomenon being present in samples from Port Hacking.

		I+	II+	III+	IV+	V+	VI+	ALL	Corrected χ^2	F
11	f	33	33	33	33	17	14	163		
	AM	12.42	14.52	13.23	14.13	14.76	16.61	15.96	6.69	3.90
	SD	3.3	4.0	3.4	3.1	2.6	2.2	3.4	20%	1%
12	f		33	33	33	24	9	132		
	AM		24.55	22.75	23.08	24.88	24.72	23.80	2.91	3.00
	SD		2.5	3.1	3.3	3.0	2.8	3.1	50%	5%
13	f			33	33	26	20	112		
	AM			30.57	31.64	34.52	34.08	32.43	1.73	15.53
	SD			2.6	2.1	2.8	2.5	3.0	50%	1%
14	f				9	26	19	54		
	AM				43.44	42.83	43.61	43.21	0.80	1.66
	SD				2.5	2.4	2.0	2.5	50%	
15	f					29	7	36		
	AM					48.59	49.04	48.68	0.003	4.56
	SD					2.4	1.4	2.4	95%	

The percentages given are of lower level of significance,
as given in Snedecor (1940)

TABLE 8 (Contd.)

E. Growth Rate - Port Hacking.

Year of Capture	Age Group	Year Brood	1st l ₁	Year of Growth	2nd i ₁	Year of Growth	3rd i ₂	Year of Growth	4th i ₃	Year of Growth	5th i ₄	Year of Growth	6th i ₅	Year of Growth
1937	II+	'35	13.58	'35										
	III+	'34	14.23	'34	11.76	'35	10.62	'36						
	IV+	'33	15.22	'33	11.90	'34	10.58	'35	8.13	'36				
	V+	'32	15.68	'32	11.50	'33	10.32	'34	9.42	'35	8.09	'36		
	VI+	'31	16.63	'31	8.75	'32	10.50	'33	10.36	'34	6.50	'35	5.50	'36
1939	I+	'38	10.58	'38										
	II+	'37	16.22	'37	12.79	'38								
	III+	'36	14.26	'36	10.18	'37	12.49	'38						
	IV+	'35	15.43	'35	8.70	'36	11.95	'37	7.58	'38				
	V+	'34	16.00	'34		'35	11.50	'36	9.88	'37	5.88	'38		
	II+	'39	14.81	'39	9.61	'40								
	III+	'38	13.52	'38	9.71	'39	7.27	'40						
	IV+	'37	12.52	'37	10.04	'38	7.38	'39	4.91	'40				
	V+	'36	13.83	'36	9.83	'37	7.67	'38	6.25	'39	3.25	'40		

Year of Growth	l ₁	Year Brood	i ₁	Year Brood	i ₂	Year Brood	i ₃	Year Brood	i ₄	Year Brood	i ₅	Year Brood
1940			9.61	'39	7.27	'38	4.91	'37	3.25	'36		
1939	14.81	'39	9.71	'38	7.38	'37	6.25	'36				
1938	12.79	'38	10.84	'37	12.00	'36	7.58	'35	5.88	'34		
1937	13.84	'37	10.31	'36	11.95	'35	9.88	'34				
1936	14.46	'36	8.70	'35	10.73	'34	8.13	'33	8.09	'32	5.50	'31
1935	14.69	'35	11.76	'34	10.58	'33	9.42	'32	6.50	'31		
1934	14.34	'34	11.90	'33	10.32	'32	10.36	'31				
1933	15.22	'33	11.50	'32	10.50	'31						
1932	15.68	'32	8.75	'31								
1931	16.63	'31										
Mean Values	14.07		10.16		8.55		7.67		7.28		5.50	

TABLE 8 (Contd.)

F. Growth Rate - Clarence River

Year of Capture	Age Group	Year Brood	1st l_1	Year of Growth	2nd i_1	Year of Growth	3rd i_2	Year of Growth	4th i_3	Year of Growth	5th i_4	Year of Growth
1937	II+	'35	12.84	'35	10.03	'36						
	III+	'34	15.67	'34	10.02	'35	8.64	'36				
	IV+	'33	11.88	'33	12.48	'34	6.00	'35	6.08	'35		
1938	II+	'36	14.56	'36	12.37	'37						
	III+	'35	14.07	'35	7.77	'36	10.27	'37				
	IV+	'34	12.50	'34	8.64	'35	6.70	'36	8.72	'37		
1939	II+	'37	13.00	'37	15.83	'38						
	III+	'36	13.30	'36	15.50	'37	7.29	'38				
	IV+	'35	13.54	'35	9.62	'36	10.07	'37	6.65	'38		
	V+	'34	15.00	'34	9.25	'35	6.10	'36	6.90	'37	6.35	'38
1940	II+	'38	12.14	'38								
	III+	'37	15.35	'37	9.70	'38	7.91	'39				
	IV+	'36	15.87	'36	9.55	'37	10.67	'38	8.00	'39		
	V+	'35	13.00	'35	5.50	'36	9.50	'37	11.00	'38	7.00	'39
1941	I+	'40	15.44	'40								
	II+	'39	15.09	'38	9.28	'40						
	III+	'38	13.36	'38	10.30	'39	8.49	'40				

Year of Growth	l_1	Year Brood	i_1	Year Brood	i_2	Year Brood	i_3	Year Brood	i_4	Year Brood
1940	15.44	'40	9.28	'39	8.49	'38				
1939	15.09	'39	10.16	'38	7.91	'37	8.00	'36	7.00	'35
1938	13.26	'38	10.50	'37	8.30	'36	7.04	'35	6.35	'34
1937	15.11	'37	12.24	'36	10.14	'35	8.20	'34		
1936	14.60	'36	9.21	'35	8.40	'34	6.08	'33		
1935	12.32	'35	10.03	'34	6.00	'33				
1934	15.64	'34	12.48	'33						
1933	11.88	'33								
Mean Values	14.08		10.00		8.43		7.60		6.57	

TABLE 9.

Period of Growth.

A. Mean Actual Lengths.

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
O	N	8.1	9.0				13.5					4.9	6.7
	S	10.0	9.2	12.0							11.4		
I+	N	22.9					29.8						
	S							17.1	19.1	20.2			
II+	N	33.9			30.2	36.1	32.3	32.4	32.6			33.5	
	S	30.7	31.3			36.3		27.8		29.5	32.2	32.5	
III+	N	35.7			38.8	38.8	34.4					36.3	33.3
	S		34.7			40.8			38.3		36.1	40.4	
IV+	N		37.7			44.5						43.5	41.9
	S	41.2				46.6					41.0	47.6	
V+	N					46.7							
	S		41.7			52.7					45.6	52.1	
VI+	N												
	S					57.0						60.0	

B. Marginal Increments.

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
mi ₁	N						14.1						
	S								7.8	8.5	9.2		
mi ₂	N	9.5			6.3	7.2	8.7	9.0	7.4			5.4	
	S	3.2	6.2			9.0			7.3		7.5	5.6	
mi ₃	N	5.2			5.6	5.2	6.5	4.7	4.0			3.0	3.8
	S		3.7			6.4			7.0		5.4	5.8	
mi ₄	N	4.3				4.2						2.8	5.2
	S		2.5			4.2					3.6	4.7	
mi ₅	N					3.0							
	S		4.7			3.2					3.6	2.9	
mi ₆	N												
	S					3.2							

In this table N stands for samples from Clarence River
and nearby localities

S stands for samples from Port Hacking and
nearby localities.

TABLE 10.

Stages of Gonad Maturation.

STAGE:	OVARY	TESTIS
<u>June-July-August.</u>		
I	Glassy, rounded, short $\frac{1}{4}$ length body cavity; few mm. only in diameter; $\frac{1}{4}$ oz. in weight.	Colourless, thin strap lying along blood vessel; c. $\frac{1}{2}$ length body cavity sharp edge.
<u>September-October.</u>		
II	$\frac{1}{4} - \frac{1}{3}$; weight $< \frac{1}{4}$ oz. generally blood shot.	Slightly wider, i.e. c. 3 mm; white.
<u>November-December.</u>		
III	$\frac{1}{3} - \frac{1}{2}$ body cavity; $\frac{1}{4}$ oz. pigmented yellow or orange..	5 mm. wide; white.
<u>January.</u>		
IV	$\frac{1}{2}$ body cavity $> \frac{1}{4}$ oz. in weight. Eggs can be dis- tinguished as discrete; half fills body cavity.	$\frac{1}{2}$ fills body cavity.
<u>February-March-April.</u>		
V	Fills body cavity. Eggs are quite separate.	Fills body cavity; milt can be expressed without difficulty.
<u>March-April-May.</u>		
VI	Running ripe eggs can be expressed by a little pressure and clear when run into sea water.	Running ripe.
<u>April-May.</u>		
VII	$\frac{1}{2}$ spent - flaccid tissue	Pale glassy edge; the testis is exhausted to flaccid.
<u>April-May-June.</u>		
VIII	Spent. Completely flaccid tissue. $\frac{1}{4}$ body cavity. Rounded and plump, blood shot yellow.	Completely flaccid.

TABLE 12.

Number of Fish of each Length at each Stage of Maturity.
(at the lower limits of the length classes).

A. <u>MALE</u> .									
Cms.	I	II	III	IV	V	VI	VII	VIII	TOTAL
25	8	8	1	-	-	1	-	1	19
26	16	8	1	-	-	-	-	-	25
27	27	25	3	-	-	-	-	1	56
28	30	26	1	-	-	-	-	1	58
29	19	20	3	-	-	-	-	-	42
30	24	25	1	1	-	-	-	-	51
31	47	37	-	-	-	-	-	-	74
32	84	47	1	3	2	1	-	-	138
33	85	67	3	-	-	3	-	-	158
34	122	76	7	1	4	4	-	-	213
35	88	69	13	4	19	15	-	-	209
36	96	64	14	7	15	25	1	1	223
37	43	43	17	10	30	18	4	1	166
38	42	41	16	11	55	29	3	-	197
39	17	33	16	12	45	36	8	1	168
40	8	21	16	6	52	14	6	-	121
41	5	9	11	13	53	22	2	-	115
TOTAL:	761	619	124	68	275	168	24	6	2035

B. <u>FEMALE</u> .									
Cms.	I	II	III	IV	V	VI	VII	VIII	TOTAL
25	1	1	-	-	-	-	-	-	2
26	4	4	1	-	-	1	1	-	11
27	1	7	6	-	-	-	-	-	14
28	7	7	-	3	1	-	-	-	18
29	7	10	2	1	-	-	1	-	21
30	6	18	4	-	-	-	-	-	28
31	13	25	7	2	-	-	-	-	47
32	19	26	4	-	-	-	-	1	50
33	18	52	4	2	-	-	-	-	76
34	39	39	2	1	2	-	-	-	83
35	24	49	4	3	1	-	-	-	81
36	33	55	6	1	2	-	-	-	97
37	18	45	4	3	2	-	-	-	72
38	24	29	11	2	9	-	-	-	75
39	23	29	5	3	13	2	-	-	75
40	15	26	5	4	12	1	-	1	63
41	3	22	3	2	11	1	-	-	43
TOTAL:	255	444	68	27	53	5	2	2	856

TABLE 13.

Sex Ratio.

Sample No.	Female	Male	Total	Ratios	
				Female	Male
N1	31	19	50	0.62	0.38
N4	48	45	93	0.52	0.48
N5	1	11	12	0.08	0.92
N6	19	53	72	0.26	0.74
N8	15	22	37	0.41	0.59
N9	1	47	48	0.21	0.79
N10	28	42	70	0.40	0.60
N16	5	9	14	0.36	0.64
N12	2	18	20	0.10	0.90
N14	1	4	5	0.20	0.80
N13	3	28	31	0.10	0.90
N19	-	5	5	0	1.00
Totals:	154	303	457	3.26	8.74
Ratios:	0.337	0.663	(Average:)	0.27	0.729
.....					
S1	16	30	46	0.35	0.65
S2	0	25	25	0	1.00
S4	0	12	12	0	1.00
S5	0	2	2	0	1.00
Totals:	16	69	85	0.35	3.65
Ratios:	0.188	0.812	(Average:)	0.087	0.913
.....					
1940					
66	21	29	50	0.42	0.58
67	32	18	50	0.64	0.36
Totals:	53	47	100	1.06	0.94
Ratios:	0.53	0.47	(Average:)	0.53	0.47
.....					
29	11	9	20	0.55	0.45
30	18	12	30	0.60	0.40
31	8	42	50	0.16	0.84
32	25	50	75	0.33	0.67
33	9	21	30	0.30	0.70
34	5	15	20	0.25	0.75
35	28	27	55	0.51	0.49
36	17	33	50	0.34	0.66
37	23	49	72	0.32	0.68
38	36	32	68	0.53	0.47
39	30	56	86	0.35	0.65
40	17	38	55	0.31	0.69
41	17	55	72	0.24	0.76
42	40	39	79	0.51	0.49

(Contd.)

TABLE 13 (Contd.)

Sample No.	Female	Male	Total	Ratios	
				Female	Male
43	6	40	46	0.13	0.87
44	45	147	192	0.23	0.77
45	30	22	52	0.58	0.42
46	15	15	30	0.50	0.50
47	30	24	54	0.56	0.44
48	31	30	61	0.51	0.49
49	9	20	29	0.31	0.69
50	20	46	66	0.30	0.70
51	27	13	40	0.67	0.33
52	32	8	40	0.80	0.20
53	11	17	28	0.39	0.61
55	44	45	89	0.49	0.51
56	11	9	20	0.55	0.45
57	25	35	60	0.42	0.58
58	23	20	43	0.54	0.46
59	63	76	139	0.45	0.55
60	14	36	50	0.28	0.72
61	20	25	45	0.44	0.56
62	24	50	74	0.32	0.68
63	24	33	57	0.42	0.58
64	11	31	42	0.26	0.74
65	14	40	54	0.26	0.74
66	14	7	21	0.67	0.33
67					
Totals:	827	1267	2094	15.38	21.60
Ratios:	0.395	0.605	(Average:)	0.416	0.584
.....					
PH1	9	41	50	0.18	0.82
PH3	8	24	32	0.25	0.75
PH4	4	9	13	0.31	0.69
PH6	1	24	25	0.04	0.96
PH7	44	121	165	0.27	0.73
PH5	1	46	47	0.02	0.98
PH9	14	19	33	0.42	0.58
PH11	2	4	6	0.33	0.67
Totals:	83	288	371	1.82	6.18
Ratios:	0.224	0.776	(Average:)	0.23	0.77
.....					
<u>AVERAGE:</u>	<u>0.336</u>	<u>0.665</u>			
<u>TOTAL:</u>	<u>1133</u>	<u>1974</u>	<u>3107</u>		
	0.365	0.635			

TABLE 14.

Mean weight of gonads (identified as being in Stage V.) and the mean of the gonad weights expressed as percentages of whole body weight.

Length cm.	FEMALE			MALE		
	Number of Fish	Mean Gonad Weights oz.	Mean 100 Gonad Wt. Whole Wt.	Number of Fish	Mean Gonad Weight oz.	Mean 100 Gonad Wt. Whole Wt.
35				2	0.4	2.3
36				3	1.1	5.4
37	1	5.5	14.9	5	1.1	5.9
38	1	1.0	5.9	12	1.0	5.2
39	2	1.8	8.6	15	1.1	5.2
40	1	2.0	7.8	15	1.4	6.3
41	1	3.8	10.5	19	1.7	6.8
42	1	1.5	4.5	16	1.7	6.7
43	6	3.1	10.0	11	1.5	6.0
44	11	3.9	11.3	13	2.0	6.3
45	16	5.6	15.2	8	2.2	6.6
46	8	4.5	12.8	5	1.7	4.8
47	12	5.4	13.1	9	2.2	5.7
48	15	5.1	12.2	2	2.6	5.9
49	10	5.3	11.6	1	2.9	6.4
50	5	6.3	12.2	-	-	-
51	7	6.9	14.0	2	3.3	6.7
52	6	6.2	11.2			
53	4	4.6	7.8			
54	5	5.7	9.4			
55	5	7.3	11.0			
56	6	9.5	13.7			
57	5	6.6	8.1			
58	2	9.5	12.2			
59	2	10.0	13.2			
60						

TABLE 15.

Tagging Experiments.

No.	Date	Locality	Series	Number of Fish
1	14.2.38	Keith's Pt. Twofold Bay	N.S.W. S.F.	6
2	15.2.38	Boggy Crk. Merimbula Lake		48
3	15.2.38	Merimbula Lake	1-228	5
4	17.2.38	Entrance Wallaga Lake		55
5	18.2.38	Entrance Tuross Lake		72
6	19.2.38	Off Horse Isl. Tuross Lake		55
7	20.2.38	Little Isl. Clyde River	229-253	25
8	20.2.38	Neat's Farm, Clyde River	254-262	9
9	21.2.38	Cullendulla Crk. Clyde Rvr.	263-278	16
10	21.2.38	Cullendulla Crk. Clyde Rvr.	279-319	41
11	21.2.38	Little Isl. Clyde River	320-401	81
12	23.2.38	Curumbene Crk. Jervis Bay	402-447	46
13	24.2.38	Comerong Bay. Crookhaven Rvr.	448-491	43
14	24.2.38	Comerong Bay, Crookhaven Rvr.	492-532	40
15	30.4.38	Gunnamatta Bay, Pt.Hacking	532-701	170
16	30.11.38	Elizabeth Isl. Clarence River	702-802	101
17	12.12.38	Mundarlow Crk. Clyde River	803-809	7
18	12.12.38	Greenwell Pt. Crookhaven Rvr.	810-838	29
19	13.12.38	Greenwell Pt. Crookhaven Rvr.	839-880	42
				872
20	5.5.39	Ballina, Richmond River	G.S.I.R. 801-846	46
21	5.5.39	Ballina, Richmond River	848-880	33
22	9.11.39	Gunnamatta Bay, Pt.Hacking*	861-1172	292
23	16.12.39	Nicholson River	1601-1620	20
24	8.2.40	Ulmarra, Clarence River	1451-1533	83
25	13.5.40	Gunnamatta Bay, Pt.Hacking	1534-1712	179
26	20.6.40	Weyba Lake Entrance, Noosa R.	1713-1804	92
27	21.6.40	Entrance Noosa River	1805-1914	110
28	21.6.40	Entrance Noosa River	1915-1949	34
				889

Forward: 1761

TABLE 15 (Contd.)

No.	Date	Locality	Series	Number of Fish
Forward:				1761
29	10.1.41	Greenwell Point	1950-1994	45
30	11.1.41	Lake Illawarra	1995-2296	100
31	2.41	Port Hacking	2401-2591	190
32	19.3.41	Hawkesbury River	2592-2600) 2297-2306	19
33	20.3.41	Lake Macquarie	2307-2400) 2601-2700) 2416	196
34	4.5.41	Clarence River	2801-2818	18
35	6.5.41	Richmond River	2715-2748	34
36	7.5.41	Tweed River	2749-2761	13
37	8.5.41	Terranora Creek	2762-2784	23
38	11.5.41	Noosa River	2785-2825	23
39	16.5.41	Terranora Creek	2826-2925	100
40	16.5.41	Curumbin Creek	2926-3126	200
				<u>961</u>
				<u>2722</u>

* This release should be less 48 fish which were placed for observation in the pond at the Division's Laboratory and were, with other fish, killed by some accident.

TABLE 16.

Tagging Recoveries.

Release:				Recapture:			Interim:		
Number	Date	Place	Length cm.	Date	Place	Length cm.	Days	Growth	Distance Travelled
M.S.W. 304	21.2.38	Cullendulla Creek	39.5	24.3.38	Cronulla	34.6	32	-	ca. 100 miles
N.S.W. 614	30.4.38	Gunnamatta Bay	29.2	7.5.38	Cronulla				
N.S.W. 621	30.4.38	" "	37.8	7.5.38	"				
N.S.W. 840	13.12.38	Crookhaven River	32.1	23.6.39	Shoalhaven	35.5	193	3.4	nil
C.S.I.R. 870	5.5.39	Richmond River	44.8	15.6.39	Richmond River	45.0	41		"
C.S.I.R. 849	"	"	42.2	6.6.39	Burleigh Hd.	49.0	32	6.8	ca. 60 "
C.S.I.R. 812	4.5.39	"	39.7	29.5.39	Cudgen	39.5	25	nil	ca. 50 "
C.S.I.R. 865	5.5.39	"	54.7	23.5.39	"	54.5	18	nil	"
C.S.I.R. 1502	8.2.40	Clarence River	31.0	8.2.40	Clarence River	30.5	nil	nil	nil
C.S.I.R. 1408	8.2.40	"	31.5	29.2.40	"	30.5	21	nil	"
C.S.I.R. 1420	8.2.40	"	29.5	8.2.40	"	29.0	nil	nil	"
C.S.I.R. 804	5.5.39	Richmond River	39.1	19.12.39	Tewantin	39.4	228	1.3	ca. 250 "
C.S.I.R. 1603	6.12.39	Nicholson River	42.0	5.3.40	Melbourne Market	48.0	113	6.3	?
C.S.I.R. 1606	6.12.39	"	38.0	25.5.40	Myall Lake	38.0	171	5.0	ca. 450 "
C.S.I.R. 844	5.5.39	Ballina	40.1	10.6.40	Brisbane Market	?	402	?	?
C.S.I.R. 1850	21.6.40	Tewantin	41.8	23.6.40	Tewantin	40.5	2	?	nil
C.S.I.R. 829	4.5.39	Ballina	39.2	17.6.40	Tweed Heads	39.2	284	nil	ca. 50 "
C.S.I.R. 1488	8.2.40	Ullmarra	31.5	1.8.40	Grafton	32.5	175	nil	nil

C. S. I. R. 1894	21.6.40	Tewantin	40.0	51.7.40	Tewantin	40.0	40	nil	nil
C. S. I. R. 1760	20.8.40	Tewantin Entrance	52.8	6.9.40	Weyba Lake	34.3	78	1.5	
C. S. I. R. 1870	21.8.40	Weyba Entrance	42.0	14.10.40	Cootharabu Lake	53	116		
C. S. I. R. 1880	21.8.40	" "	45.5	4.9.40	Noosa Heads	37	76		
C. S. I. R. 1815	21.8.40	" "	38.5	6.11.40	Weyba Lake	38.7	158	0.4	
C. S. I. R. 1645	15.5.40	Cronulla	29.0	8.11.40	Cronulla	27.7	179		
C. S. I. R. 890	9.11.39	Gunnamatta Bay	25.0	15.9.40	Millet Creek	28.5	311	{ Possibly to 5-6	
C. S. I. R. 1092	"	" "	25.0	"	" "	31.0	"		
C. S. I. R. 1546	13.5.40	" "	30.0	15.9.40	" "		125		ca. 40 miles
C. S. I. R. 1553	"	" "	30.0	"	Hawkesbury River		"	"	"
C. S. I. R. 1555	"	" "	30.0	"	" "		"	"	"
C. S. I. R. 1559	"	" "	31.6	"	" "		"	"	"
C. S. I. R. 1565	"	" "	29.9	"	" "		"	"	"
C. S. I. R. 1566	"	" "	29.2	"	" "		"	"	"
C. S. I. R. 1568	"	" "	30.1	"	" "		"	"	"
C. S. I. R. 1577	"	" "	30.2	"	" "		"	"	"
C. S. I. R. 1578	"	" "	29.8	"	" "		"	"	"
C. S. I. R. 1579	"	" "	26.6	"	" "		"	"	"
C. S. I. R. 1580	"	" "	30.9	"	" "		"	"	"
C. S. I. R. 1586	"	" "	32.8	"	" "		"	"	"
C. S. I. R. 1588	"	" "	28.0	"	" "		"	"	"
C. S. I. R. 1591	"	" "	30.4	"	" "		"	"	"
C. S. I. R. 1592	"	" "	31.2	"	" "		"	"	"

* C. S. I. R. 890 - 1709 when recaptured ranged in size from 28.5-31.0 cm.

(Contd.)

TABLE 16 (Contd.)

Tagging Recoveries.

Number	Release:			Recapture:			Interim:		
	Date	Place	Length cm.	Date	Place	Length cm.	Days	Growth	Distance Travelled
C.S.I.R. 1595	15.5.40	Gunnamatta Bay	29.7	15.9.40	Hawkesbury River		125	?	ca. 40 miles
C.S.I.R. 1621	"	"	31.1	"	"		"	"	"
C.S.I.R. 1625	"	"	28.4	"	"		"	"	"
C.S.I.R. 1626	"	"	32.0	"	"		"	"	"
C.S.I.R. 1635	"	"	25.4	"	"		"	"	"
C.S.I.R. 1640	"	"	28.7	"	"		"	"	"
C.S.I.R. 1647	"	"	31.4	"	"		"	"	"
C.S.I.R. 1650	"	"	29.2	"	"		"	"	"
C.S.I.R. 1653	"	"	31.3	"	"		"	"	"
C.S.I.R. 1656	"	"	31.0	"	"		"	"	"
C.S.I.R. 1658	"	"	28.1	"	"		"	"	"
C.S.I.R. 1667	"	"	31.9	"	"		"	"	"
C.S.I.R. 1672	"	"	28.2	"	"		"	"	"
C.S.I.R. 1677	"	"	30.8	"	"		"	"	"
C.S.I.R. 1684	"	"	29.8	"	"		"	"	"
C.S.I.R. 1709	"	"	29.9	"	"		"	"	"
C.S.I.R. 1780	20.6.40	Noosa River	34.1	26.12.40	Lake Coorribah	55.0	189	nil	-
C.S.I.R. 1907	21.6.40	"	39.6	6.1.41	" Weyba	45.0	201	8.6	nil
C.S.I.R. 1772	20.6.40	"	37.2	7.1.41	" Weyba	39.5	201	4.3	nil

TABLE 17.

The Relative Catches of Sea-Mullet and of River-Mullet.

A. N.S.W., Twelve Months ended 30th June, 1939.

Locality	Total Catch*	Catch for April, May, June*	Percentage Sea-Mullet to Total Mullet†		Percentage Locality Catch	
			A.	B.	Total Mullet	Mullet April, May, June
	Boxes	Boxes				
Tweed River	9,712	4,244	35.0	43.7	11.9	13.4
Cudgen Creek	512	472	73.8	92.2	0.6	1.5
Moball Creek	470	331	56.4	70.4	0.6	1.0
Richmond River	3,181	597	15.0	18.8	3.9	1.9
Byron Bay	1,239	1,238	79.9	100.0	1.5	3.9
Clarence River	16,223	5,732	28.3	35.3	19.9	18.1
Nambucca River	1,582	1,245	62.9	78.7	1.9	3.9
Macleay River	3,169	630	21.4	26.8	2.9	2.0
Camden Haven	4,122	850	16.5	20.6	5.0	2.7
Manning River	2,037	498	19.5	24.4	2.5	1.6
Wallis Lake	7,071	2,039	23.3	29.1	8.6	6.5
Lower Port Stephens	4,325	1,500	27.7	34.7	5.5	4.7
Upper Port Stephens	418	24	4.3	5.7	0.5	-
Lake Macquarie	1,569	654	33.4	41.7	1.9	2.1
Tuggerah Lake	6,234	4,362	56.0	70.0	7.6	13.8
Hawkesbury Rvr.	2,023	650	25.7	32.1	2.5	2.1
Pittwater	1,014	284	22.3	28.0	1.2	0.9
Port Jackson	640	11	1.4	1.7	0.8	-
George's River	1,699	306	14.4	18.0	2.8	1.0
Lake Illawarra	1,412	797	45.2	56.4	1.7	2.5
Port Kembla	632	420	53.2	66.4	0.8	1.3
Crookhaven River	641	69	8.6	10.8	0.8	0.2
Shoalhaven River	711	132	14.9	18.6	0.9	0.4
Jervis Bay	458	286	50.0	62.4	0.6	0.9
St. George's Bas.	1,133	247	17.4	21.7	1.4	0.8
Tuross Lake	725	187	20.7	25.8	0.9	0.6
Wallaga Lake	632	91	11.6	14.4	0.8	0.3
Twofold Bay	709	300	33.9	42.3	0.9	0.9
Other (44 localities)	5,135	2,346	36.6	45.7	6.3	7.4
Total	79,428	30,542	31.4	39.2		

* Figures taken from N.S.W. Fish Rept. 1940. A box is taken to hold 70 lb.

† Sea-Mullet assumed in A. to be 80% of catch in April, May, June.
in B. to be 100% of the catch of those months.

TABLE 17 (Contd.)

B. Queensland, Twelve Months ended 30th December, 1939.

Locality	Total Mullet Receivals*	Receivals May, June, July	Percentage Sea-Mullet to Total Mullet Receivals†		Percentage Locality Catch	
					Total Mullet	Mullet May, June July
	lb.	lb.	A.	B.		
Tweed Heads	334,394	131,362	31.4	39.3	15.2	13.7
Southport	160,179	57,500	28.7	35.9	7.2	6.0
Coomera	233,972	87,666	30.7	38.3	10.6	9.4
Cleveland	109,230	31,140	22.8	28.5	4.9	3.2
Wynnum	502,773	241,184	38.3	48.0	22.7	25.2
Brisbane	38,624	17,568	36.3	45.5	1.7	1.8
Sandgate	12,823	3,174	19.8	24.8	0.6	0.3
Redcliffs	87,155	55,565	51.0	63.8	3.9	5.8
Bribie Island	35,280	15,523	35.2	44.0	1.6	1.6
Caloundra	261,808	174,568	53.3	66.7	11.8	18.2
Maloochydore	66,648	35,877	43.1	53.8	3.0	3.7
Tewantin	247,085	49,208	15.9	19.9	11.2	5.1
Tin Can Bay	53,443	30,330	45.4	56.8	2.4	3.2
Maryborough	40,960	18,285	35.7	44.6	1.8	1.9
Bundaberg	3,748	1,705	40.7	50.8	0.2	0.2
Gladstone	17,424	5,980	2.75	34.3	0.8	0.6
Mackay	8,955				0.4	
Total	2,214,501	956,635	34.7	43.4		

* Figures supplied by Mr. R.F. Thompson, Chairman, Brisbane Fish Board. The figures represent receivals of fish at the Brisbane Metropolitan Fish Markets.

† Sea-Mullet taken in A. to be 80% of May, June, July receivals.
in B. to be 100% of receivals of those months.

TABLE 18.Percentage of Mullet Catch to Total Catch at Important Centres.A. N.S.W., Centres North of Newcastle.

Place	1937			1938		
	Total Catch	Mullet	Percentage Mullet to all Fish	Total Catch	Mullet	Percentage Mullet to all Fish
	tons	tons		tons	tons	
Tweed River	310	240	77.4	352	253	71.9
Terranora Creek	68	58	85.3			
Richmond River	227	150	66.1	178	108	60.7
Evans River	32	5	15.6	44	8	18.2
Byron Bay	88	16	18.1	76	25	32.9
Glarence River	734	531	72.3	817	664	81.3
Bellinger River	23	13	56.5	59	8	13.6
Coff's Harbour	79	5	3.8	49	0.1	0.2
Nambucca River	86	30	34.9	72	27	37.5
Hastings River	139	85	61.2	121	67	55.4
Macleay River	257	156	60.7	238	112	47.1
Camden Haven	251	201	80.1	266	191	71.8
Manning River	231	83	35.9	229	63	27.5
Wallis Lake	395	204	51.6	408	225	55.2
Lower Pt. Stephens	236	98	41.5	351	140	39.9
Myall River						
Upper Pt. Stephens	22	14	63.6	31	21	67.7
Other Waters	93	73	78.5	81	41	50.6
Total	3271	1962	53.1	3372	1953	57.9

N.S.W. Hastings River:-

1880	40%	1907	34%
1905	33%	1908	43%
1906	41%	1909	42%
1910	53%		

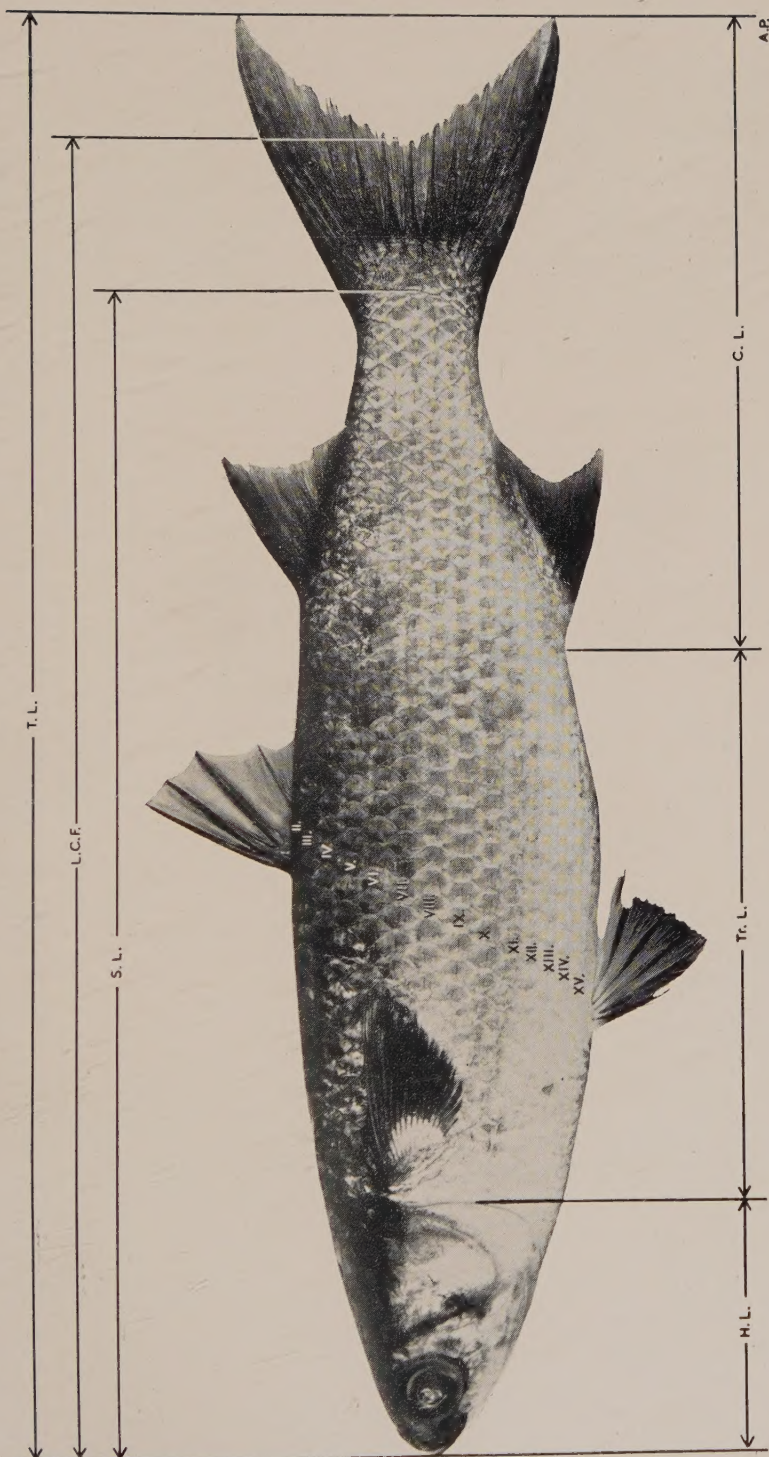
TABLE 18 (Contd.)B. Queensland, Market Receipts.

Year	Total Receipts	Mullet	Percentage of Mullet to all Fish	
	tons	tons		
1924-25	1,500	1,200	80.0	1.
1925-26	1,400	1,060	75.7	
1926-27	1,640	1,225	74.6	
1927-28	1,790	1,350	75.4	
1928-29	1,890	1,410	74.6	
1929-30	1,660	1,250	75.2	
1930-31	1,970	1,460	74.2	
1931-32	1,850	1,380	74.5	
1932-33	1,680	1,260	74.9	
1933-34	1,610	1,210	75.1	
1934-35	-	-		
1935-36	1,544	-		
1936-37	2,005	1,050	52.5	2.
1937-38	2,119	1,110	52.1	
1938-39	2,198	1,090	47.5	
1939-40	2,041	970	44.4	

1. Figures from Lindsey et al. (1934).

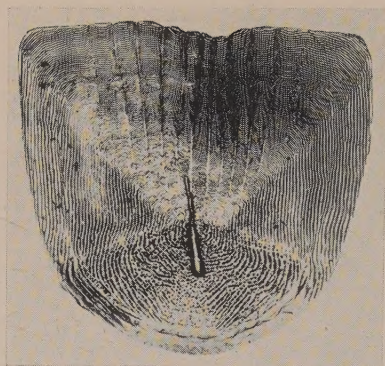
2. Figures from Annual Reports of Brisbane Fish Board.

PLATE 1.

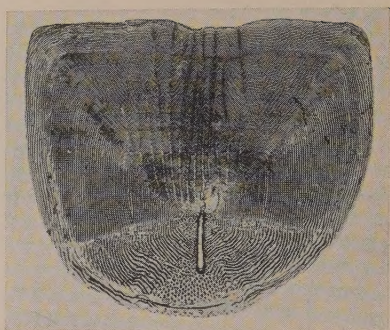


Mugil dobula—Showing the method of taking proportional measurements, and the method of enumerating scales.

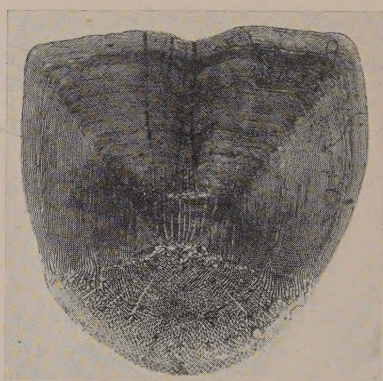
PLATE 2.



(a)



(b)



(c)



(d)



(e)

Scales of *M. Dobula*—

(a)—I +, 25 cm. (b)—II +, 26 cm. (c)—III +, 38 cm. (d)—IV +, 40 cm.
(e)—V + ?, 42 cm.

The following list gives the
BULLETINS
numbered from 76 onwards.

A full list of the Council's publications is issued as a Supplement to the Council's Journal for February each year.

76. A Soil Survey of the Hundreds of Laffer and Willalooka, South Australia
77. Studies on the Phosphorus Requirements of Sheep.—I.
78. Methods for the Identification of the Light-coloured Woods of the Genus *Eucalyptus*
79. The "Lucerne Flea" *Smynturus viridis* L. (Collembola) in Australia
80. The Establishment, Persistency, and Productivity of Selected Pasture Species on an Irrigated Reclaimed Swamp
81. A Comparative Study of *Lolium perenne* and *Phalaris tuberosa* at Varying Stages of Growth
82. The Insect Inhabitants of Carrion: A Study in Animal Ecology
83. Natural Pastures: Their Response to Superphosphate
84. The Basal (Standard) Metabolism of the Australian Merino Sheep.—II.
85. Studies on the Phosphorus Requirements of Sheep.—II. (Out of print)
86. A Soil Survey of the Berri, Cobdogla, Kingston, and Moorook Irrigation Areas, and of the Lyrup Village District, South Australia
87. Radio Research Board: Report No. 6
88. Radio Research Board: Report No. 7
89. Radio Research Board: Report No. 8
90. The Identification of the Principal Commercial Australian Timbers other than Eucalypts
91. Further Investigations into the Transport of Bananas in Australia
92. The Apple-growing Soils of Tasmania. Part 1: A General Investigation of the Soils. Part 2: A Soil Survey of Part of the Huonville District
93. Studies on Contagious Pleuro-Pneumonia of Cattle.—I.
94. Fertility in Sheep: Artificial Production of Seminal Ejaculation and the Characters of the Spermatozoa contained therein
95. Radio Research Board: Report No. 9
96. Observations on Myxomatosis Cuniculi (Sanarelli) made with a View to the Use of the Virus in the Control of Rabbit Plagues
97. Studies on Contagious Pleuro-pneumonia of Cattle.—II., II. (a), II. (b), III.
98. *Cercospora* Leaf-Spot (Frogeye) of Tobacco in Queensland
99. A Survey of the Pastures of Australia
100. Radio Research Board: Report No. 10
101. Radio Research Board: Report No. 11.
102. Studies of Selected Pasture Grasses: The Measurement of the Xero-phitism of any Species
103. *Wojnowicia graminis* (McAlp.) Sacc. and D. Sacc. in Relation to Foot Rot of Wheat in Australia
104. Investigations on the Occurrence and Inheritance of the Grass Clump Character in Crosses between Varieties of *Triticum vulgare* (Vill.)
105. Investigations on the Associated Growth of Herbage Plants
106. Investigations on "Spotted Wilt" of Tomatoes.—III. Infection in Field Plots
107. A Soil Survey of the Coomealla, Wentworth (Curlwaa), and Pomona Irrigation Settlements, N.S.W.
108. The Basaltic Soils of Northern Tasmania
109. The Variability of Plant Density in Fields of Wheat and its Effect on Yield
110. Radio Research Board: Report No. 12
111. Radio Research Board: Report No. 13
112. Studies in Fertility of Sheep
113. Studies on Coast Disease of Sheep in South Australia
114. The Wood Structure of some Australian Rutaceae with Methods for their Identification
115. A Soil Survey of Part of the Denmark Estate, Western Australia
116. The Relation of Phosphate to the Development of Seeded Pasture on Podsolised Sand
117. The Regional and Seasonal Incidence of Grasshopper Plagues in Australia

BULLETINS—*continued*

118. A Soil Survey of the Horticultural Soils in the Murrumbidgee Irrigation Areas, N.S.W.
119. The Wood Structure of some Australian Cunoniaceae with Methods for their Identification
120. Some Effects of Green Manuring on Citrus Trees and on the Soil.
121. Observations on the Toxicity of Fluorine for Sheep
122. The Establishment of Pastures on Deep Sands in the Upper South-East of South Australia
123. A Soil Survey of the Merbein Irrigation District, Victoria
124. The Wood Anatomy of Some Australian Meliaceae with Methods for their Identification
125. A Soil Survey of Part of the Kerang Irrigation District, Victoria
126. Investigations on Chilled Beef. Part I.—Microbial Contamination Acquired in the Meatworks
127. Radio Research Board: Report No. 14
128. An Investigation of the Problems of Salt Accumulation on a Mallee Soil in the Murray Valley Irrigation Area
129. Investigations on Chilled Beef. Part II.—Cooling and Storage in the Meatworks
130. Chemical Investigations on the Fleece of Sheep
131. Black End and Anthracnose of the Banana with Special Reference to *Gloeosporium musarum* Cke. and Mass.
132. The Wood Anatomy of Some Australian Lauraceae with Methods for their Identification
133. A Soil Survey of the Mildura Irrigation Settlement, Victoria
134. Studies on Bovine Mastitis. 1.—Study of an Experimental Herd
135. Investigations on the Storage of Jonathan Apples grown in Victoria
136. Experimental Studies of Ephemeral Fever in Australian Cattle
137. A Soil Survey of the Red Cliffs Irrigation District, Victoria
138. The Economic Biology of Some Australian Clupeoid Fish
139. The Soils of Tasmania
140. Foot-Rot in Sheep: A Transmissible Disease due to Infection with *Fusiformis nodosus* (n. sp.). Studies on Its Cause, Epidemiology, and Control
141. A Soil Survey of the Waikerie Irrigation Area, South Australia
142. A Soil and Land Use Survey of the Hundreds of Riddoch, Hindmarsh, Grey, Young, and Nangwarry, County Grey, South Australia
143. Production of Dried Grapes in Murray Valley Irrigation Settlements. 1.—Viticulture
144. Interference in a Wind-Tunnel of Octagonal Section
145. Friction and Lubrication: Report No. 1
146. An Analysis of the Outbreaks of the Australian Plague Locust (*Chortoicetes terminifera* Walk.) during the Seasons 1937-38 and 1938-39
147. Enzootic Ataxia and Copper Deficiency of Sheep in Western Australia
148. Studies in Fertility in Sheep. 2. Seminal Changes Affecting Fertility in Rams
149. Production of Dried Grapes in Murray Valley Irrigation Settlements. 2. Irrigation, Drainage, and Reclamation
150. The Soils of the Parishes of Longford, Cressy, and Lawrence, County Westmorland, Tasmania
151. The Control of St. John's Wort (*Hypericum perforatum* L. var. *angustifolium* D.C.) by Competing Pasture Plants
152. Soil Survey of Part of County Moira, Victoria, including the Parishes of Boosey, Cobram, Katamatite, Naringaningalook, Katunga, Yarroweyah, and Strathmerton
153. Pelagic Tunicates, in the Plankton of South-eastern Australian Waters, and Their Place in Oceanographic Studies
154. The Handling and Storage of Australian Oranges, Mandarins, and Grapefruit
155. Friction and Lubrication: Report No. 2. The Lubricating Effect of Thin Metallic Films and the Theory of the Action of Bearing Metals
156. Standardized Plant Names.
157. Studies in the Biology of Australian Mullet. 1.